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University
of Toronto

Faculty of Applied Science and Engineering

Calendar 1970-1971

University of Toronto Press
1970

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CALENDAR 1970

January

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CALENDAR 1971

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August

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September

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November

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December

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I

Calendar 1970-1971

FALL TERM, 1970

July 1	Wednesday	Dominion Day. Buildings closed.
August 3	Monday	Civic Holiday. Buildings closed.
August 24	Monday	Students of the III Year, Course 1, report at Survey Camp.
August 31	Monday	Students of the III Year, Course 9, report at Survey Camp. Fall examinations commence.
September 1	Tuesday	Students in II Year, Course 6, report for Analytical Chemistry Lab.
September 7	Monday	Labour Day. Buildings closed.
September 10	Thursday	Registration in person of the I Year from 9:30 a.m. to 12 noon and from 2:00 p.m. to 4:30 p.m. in the Galbraith Building. Meeting of Faculty Council.
September 11	Friday	Registration in person of the II Year from 9:30 a.m. to 12 noon and of the III Year from 2:00 p.m. to 4:30 p.m. in the Galbraith Building. Dean's address to the I Year at 9:00 a.m. in Convocation Hall. Preliminary instruction to the I Year.
September 12	Saturday	Registration in person of the IV Year from 9:30 a.m. to 12 noon in the Galbraith Building.
September 14	Monday	Lectures and laboratory work commence at 9:00 a.m.
September 21	Monday	Opening address by the President to the students of all Faculties at 2:00 p.m. in Convocation Hall. Lectures and laboratory classes withdrawn from 1:45 p.m. to 3:10 p.m.
October 1	Thursday	Meeting of Faculty Council.
October 9	Friday	Meeting of Senate.
October 12	Monday	Thanksgiving Day. Buildings closed.
November 4	Wednesday	Meeting of Faculty Council.
November 11	Wednesday	Remembrance Day.

November 13	Friday	Meeting of Senate.
November 26	Thursday	IV Year Employment Interviews.
November 27	Friday	IV Year Employment Interviews.
November 28	Saturday	IV Year Employment Interviews.
December 1	Tuesday	Meeting of Faculty Council.
December 11	Friday	Last day of lectures for Fall Term. Meeting of Senate.
December 14	Monday	
to		
December 22	Tuesday	Study period and examinations in Fall Term courses.
December 25	Friday	Christmas Day. Buildings closed.

SPRING TERM 1971

January 1	Friday	New Year's Day. Buildings closed.
January 4	Monday	Spring Term begins.
January 8	Friday	Meeting of Senate.
January 12	Tuesday	Meeting of Faculty Council.
January 15	Friday	Last day for payment of the second instalment of fees.
February 3	Wednesday	Meeting of Faculty Council.
February 12	Friday	Meeting of Senate.
February 15	Monday	
to		
February 19	Friday	Study week. Lectures and laboratory classes withdrawn.
March 4	Thursday	Meeting of Faculty Council.
March 12	Friday	Meeting of Senate.
April 4	Monday	Meeting of Faculty Council.
April 8	Thursday	Last day of lectures for Spring Term.
April 9	Friday	Good Friday. Buildings closed.
April 19	Monday	Annual Examinations commence.
May 4	Tuesday	Meeting of Faculty Council.
May 14	Friday	Meeting of Senate.
May 24	Monday	Victoria Day. Buildings closed.

II

The Faculty of Applied Science and Engineering

ADMINISTRATIVE STAFF

Dean: J. M. Ham, B.A.SC., S.M., SC.D.(M.I.T.)
Executive Assistant and Secondary Schools Liaison Officer:
J. S. Hewitt, B.SC.(QU.), M.S., PH.D.(BIRM.)
Associate Dean: G. B. Craig, M.A.SC., PH.D.
Assistant Dean and Secretary: J. A. Gow, B.A.SC.
Assistant Secretary: W. J. Dowkes, B.A.SC.

The Faculty of Applied Science and Engineering in the University of Toronto offers the widest range of undergraduate and postgraduate studies in engineering in Canada. The four year Bachelor of Applied Science (B.A.Sc.) undergraduate program is offered in Civil, Chemical, Electrical, Geological, Industrial and Mechanical Engineering, in Metallurgy and Materials Science and in Engineering Science. The Engineering Science program offers specific options in Aerospace, Chemical, Computer Science, Electrical, Geophysics, Materials Science, Nuclear and Thermal Power and Physics.

The Faculty offers, through the School of Graduate Studies, postgraduate programs for the Master of Applied Science (M.A.Sc.), the Master of Engineering (M.Eng.) and the Doctor of Philosophy (Ph.D.). Through the immense diversity of the resources of the University it is possible to do research in bio-engineering (engineering and medicine), in environmental engineering (urban planning and the control of pollution in air, water and land), in the history of technology, etc. This remarkable pattern of bridges linking the arts, sciences and professions in studies of man, his ideas and works adds a distinctive vitality and range to engineering at Toronto.

There are some 2200 undergraduate students and 600 postgraduate students. Undergraduates are taught not only by the staff of the Faculty but also by staff of University departments in Chemistry, Geology, Mathematics, Physics, English, History, Philosophy and Political Economy. On the staff of the Faculty alone there are some 160 professors.

From its historic beginnings in the School of Practical Science (S.P.S.) in the eighteen-seventies, the Faculty has grown since 1906 as an integral and senior part of the University. For students an important historical fact is that the Engineering Society, the student society of the Faculty, with its "Cannon" and "LGMB" band, is the oldest engineering organization of any formal kind in Canada.

The Faculty is located on the main campus in a rectangle bounded on the south by College Street, the west by St. George Street, the north by Convocation Hall and on the east by Taddle Creek Road where, in the days of Canadian Confederation there was indeed a creek so named.

The administrative offices are located in the southwest corner of the Galbraith Building at 35 St. George Street. Students and visitors may obtain information and assistance here.

SUMMARY OF STUDENTS IN ATTENDANCE — *Session 1969–1970*

COURSE	1	3	4	5	6	7	8	9	TOTAL
Year I	87	88	51	140	90	117	20	12	600
II	78	103	82	73	95	143	21	16	611
III	63	83	97	58	84	130	8	9	532
IV	64	67	85	56	76	89	6	8	451
TOTAL	292	341	315	327	345	479	55	45	2199
Special Students									7

III

General Information Admission and Registration

Full details of the University of Toronto undergraduate admissions are contained in the Undergraduate Admission Handbook 1970–71 obtainable on request from the Office of Admissions, University of Toronto, Toronto 181, and available in all Ontario secondary schools. Inquiries about admission to the Faculty of Applied Science and Engineering should be directed to the above-mentioned office.

The right is reserved to limit the number of students admitted to any course in the Faculty.

1. ADMISSION REQUIREMENTS

ONTARIO GRADE 13 REQUIREMENTS:

Standing in the following subjects, with an overall average of 70% for Engineering Science, and 64% for all other courses:

Mathematics (A and B); Physics; Chemistry; and an additional subject or subjects comprising 2 credits selected from the Grade 13 subjects approved for purposes of admission to the University.

It is strongly recommended that Ontario Grade 13 candidates have Grade 12 standing in at least six subjects (excluding Physical Education). The subjects chosen should include at least five of the following subjects and at least one subject from each of the four groups.

i English
ii French; German; Greek; Italian; Latin; Russian; Spanish
iii History (Parts 1 and 2); Geography (Parts 1 and 2)
iv Mathematics (Parts 1 and 2); Science (Physics and Chemistry)

The above requirements are applicable to candidates seeking admission to the session 1970–71. Commencing in the session 1971–72 admission will be granted, depending on the number of places available, to candidates from Ontario secondary schools who demonstrate good standing, based upon the following evidence:

(i) Completion of secondary school studies, including a full year of academic work at the Grade 13 level. The Grade 13 program should include Mathematics A, Mathematics B, Physics and Chemistry, but students who have substituted another subject for one of the latter three subjects will also be considered. For admission to the program in Engineering Science, superior standing is required.

(ii) A recommendation by the secondary school last attended regarding fitness for university studies.
(iii) A complete academic report for the three final years of secondary school.
(iv) Results of standardized tests offered by the Service for Admission to College and University.

2. APTITUDE AND ACHIEVEMENT TESTS

Ontario students will present the results of all standardized tests offered in the secondary schools. Other students may improve their competitive position by taking the aptitude test of the College Entrance Examination Board, Box 592, Princeton, New Jersey 08540, U.S.A.

3. EQUIVALENT CERTIFICATES

The following certificates are usually accepted as equivalent to Ontario Grade 13 although individual subjects cannot always be equated. Candidates offering Senior Matriculation programs from provinces other than Ontario must offer at least five subjects and satisfy the subject requirements specified for the course of their choice. Specific details on subjects and standards required for the course must be requested well in advance of the application deadline.

CANADA:

Alberta, Manitoba, Nova Scotia, Saskatchewan – Grade 12.
British Columbia, New Brunswick – Grade 13, or First Year University
Newfoundland – First Year Memorial University.
Prince Edward Island – First Year at the University of Prince Edward Island.
Quebec – Senior High School Leaving Certificate; appropriate C.E.G.E.P. program; English Catholic Senior High School Leaving Certificate (5th Year High – Grade 12), First Year C.E.G.E.P.
Other certificates will be considered.

ENGLAND, WEST INDIES, EAST AND WEST AFRICA, HONG KONG

Standing in five subjects, of which at least two must be at advanced level, or standing in four subjects of which at least three must be at advanced level on the following certificates. In either case passes are required in Physics, Chemistry, and an acceptable mathematics subject. At least two of these must be at advanced level.

(i) General Certificate of Education.
(ii) School and Higher School Certificates.
(iii) University of Hong Kong Matriculation Certificate.
(iv) Hong Kong English School Certificate from 1965, renamed the Certificate of Education (English) in 1968. Advanced-level standing in appropriate subjects is required in addition.

INDIA, PAKISTAN

B.Sc. with high standing.

UNITED STATES, CENTRAL AND SOUTH AMERICA

First Year University standing (normally 30 semester hours) in acceptable subjects from an accredited institution. Students with high school diploma and C.E.E.B. Advanced Placement examinations will be considered.

4. ENGLISH FACILITY

Candidates whose mother tongue is not English may be required to meet an appropriate standard in a recognized test of English facility such as the University of Michigan English Language Test, the Certificate of Proficiency in English issued by the Universities of Cambridge or Michigan, or the Test of English as a Foreign Language (T.O.E.F.L.).

5. MATURE STUDENTS

Candidates 25 years of age or older who have lived in Ontario for a minimum period of one year may request special consideration if they have not completed the regular admission requirements in full. In order to be admitted to the Faculty of Applied Science and Engineering all such candidates must have Grade 13 or equivalent preparation in mathematics, physics and chemistry. Interested candidates should consult the Office of Admissions for further information.

6. APPLICATION PROCEDURES

All Candidates must submit an application form and supporting documents to the Office of Admissions, University of Toronto, Toronto 181.

Supporting documents include all final secondary school certificates held. These certificates must indicate the subjects studied and grades obtained. If a certificate is not available at the time of application, candidates must indicate the exact name of the certificate to be presented for admission, and the subjects included therein, as well as the approximate date available. A notarized English translation must accompany certificates which are in a language other than English or French.

In addition a student who has previously attended a University must submit the following:

(*a*) Official transcripts issued by the University or College previously attended, giving in detail the courses completed, with the standing and grades in each. Transcripts or a supporting letter from the Registrar of the University or College must indicate that the candidate has been granted honourable dismissal and is eligible for re-admission to the institution concerned in the session for which he seeks admission to the University of Toronto;

(*b*) Official statements or calendars giving full information on the content of the University courses covered by the transcripts submitted.

For application forms and further information about admission requirements, consult the Office of Admissions, stating in the first letter what credentials will be offered with a listing of subjects and grades obtained.

The closing date for the receipt of applications is June 1. Only in circumstances which the Committee on Admissions deems exceptional will a late application be considered.

7. EARLY ADMISSION

(Ontario Grade 13 students only)

Ontario Grade 13 students with good school records may be offered admission as early as June 11.

Students wishing to be considered for Early Admission should ensure that their applications are forwarded by their schools not later than April 1.

8. CANDIDATES WHO HAVE PREVIOUSLY FAILED IN UNIVERSITY WORK

Candidates with a previous failure in university work may be considered individually on their merits; candidates with two previous failures are normally refused admission.

9. PROCEDURE FOR REGISTRATION

Detailed instructions concerning registration will be mailed to returning and newly admitted students before the beginning of each academic year.

10. HEALTH REQUIREMENTS

Every person admitted to the University as an undergraduate must, at the time of his or her first medical examination by the University Health Service, present satisfactory evidence of successful vaccination within three years prior to the date of the examination, or must be vaccinated by the examining physician.

COLLEGES

With the establishment of New College and Innis College, which are open to students of all faculties, it is now possible for students of the Faculty of Applied Science and Engineering to become members of a college. Membership in a college is not obligatory, and application for membership is at the option of the student.

Students entering the First Year who are interested in becoming members of either college should indicate their choice in the space provided on the University's admission application form. A college fee of $15 is required upon acceptance.

The facilities of Innis College and New College are described below.

INNIS COLLEGE

Innis College was constituted on July 1, 1964, and admitted its first students in the following September. It is a multi-faculty college of the University of Toronto, and includes undergraduate students in all Faculties and Schools of the University.

A special feature is the Writing Laboratory. This service offers assistance to Innis College students in the skills and methods of writing essays and other academic reports. A staff of experienced teachers is available to give individual instruction.

The College has limited residential space available in houses on campus. Separate application for residence accommodation must be made directly to the Residence Co-ordinator of Innis College.

Students entering First Year will be invited to apply for membership after they have been accepted into their Faculty or School. Students entering the Second to Fourth Years who wish to join the College should obtain an application form from the Registrar, Innis College, University of Toronto.

A special college fee of $15 is payable to the Chief Accountant of the University of Toronto. This payment is made after the applicant has received notice of his acceptance by Innis College.

NEW COLLEGE

New College is a multi-faculty co-educational college; in addition to students from the Faculty of Arts and Science those from other Faculties and Schools are eligible for membership. This gives students from all divisions of the University the opportunity to participate in the activities of a college and to associate with students in other fields of study. Tutorial classes are provided for First Year students in some subjects.

The new building, centrally located on the west campus, provides academic, social and dining facilities for all members of the College and in addition accommodates nearly 300 male students in residence.

Students applying for membership in the College who wish accommodation in the Residence must apply on the prescribed form which may be obtained from the Dean of Students, New College.

RESIDENCE ACCOMMODATION

DEVONSHIRE HOUSE

Devonshire House, the University Residence for Men, accepts students from all Faculties. The facilities of the residence include a library, music listening room, music practice room, common rooms, kitchenettes, laundry room, television and games rooms. It does not have a dining hall. Members may take their meals at Hart House, Howard Ferguson Hall, or New College, all located nearby.

Application forms may be obtained from the Secretary to the Dean, Devonshire House, University of Toronto. Application should be made as early as possible.

NEW COLLEGE

The residence facilities of New College, and the procedure for application, are described in the entry under Colleges, above.

OTHER COLLEGES

Each of the four Arts Colleges also maintains a Men's Residence, into which some engineering students may be accepted. Further information may be obtained from University College – Dean of Men; Victoria College – Senior Tutor; Trinity College – Registrar, Trinity College; St. Michael's College – Dean of Men.

HOUSING SERVICE

For the convenience of those students who are not able to find accommodation in the University and College residences, the University Housing Service maintains a listing of rooming houses, flats, apartments and homes. Information may be obtained by telephoning 928-2542.

Off-campus housing of this nature is not subject to University regulation. However every effort is taken to make the information on the accommodation as complete as possible and students are encouraged to assist in this effort by reporting on the quality of the accommodation that they have occupied.

CAMPUS CO-OPERATIVE RESIDENCE INCORPORATED offers residence and apartment accommodation for graduate and undergraduate students. Total occupancy is 300 in residence, half male, half female, and 50 in apartments. Meals are provided, and non-residents are invited to eat at the Co-op Dining Rooms. Since the University of Toronto has no official connection with Campus Co-operative Residence, Inc., inquiries should be addressed direct to Campus Co-operative Residence Incorporated, 395 Huron Street, Toronto 181, Ontario.

ROCHDALE COLLEGE offers student accommodation of varying forms. Single and double rooms, suites, and apartments will be offered at reasonable rates. Total accommodation will be about 850 students, both male and female. A large cafeteria is contained within the building. Students may take advantage of the educational program of Rochdale College on either a full or part-time basis if they so desire. Since the University of Toronto has no official connection with Rochdale College, all inquiries should be addressed direct to Rochdale College, Reservations Office, 395 Huron Street, Toronto 181, Ontario.

TARTU COLLEGE

Tartu College opened September, 1969, to offer accommodation to single graduate and professional faculty students. 444 single rooms and 15 double rooms are available. Groups of six will have their own cooking facilities. Single rooms will be $85 a month and doubles $75 a month. A rebate system brings the rents down to $70 and $60 per month respectively, if the residents do their own cleaning and stay the full 12 months. Tartu College is located at the corner of Madison Avenue and Bloor Street. Since the University of Toronto has no official connection with Tartu College, all enquiries should be addressed direct to Mr. G. C. Sloan, Reservations Office for Tartu College, 39 Prince Arthur Avenue, Toronto, Ontario. Telephone: 925-2420.

ST. ANDREW'S-UNIVERSITY DAY NURSERY

This day nursery, established and supported by the University of Toronto, the Graduate Students' Union and the Students' Administrative Council, provides preschool education and day care facilities for children of University of Toronto students. Children aged two to five years are accepted.

The nursery, located at St. Andrew's United Church, 117 Bloor Street East, is well equipped and staffed and is licensed under the Day Nursery Act, Province of Ontario. It operates from 8:30 a.m. to 5:45 p.m. throughout the winter and summer academic sessions. Fees are reasonable, and noon meals and morning and afternoon snacks are provided.

Priority of enrolment is given to children of University students, although children of other members of the University community will be considered.

Information may be obtained from the nursery (telephone 921-7078) or from the School of Graduate Studies.

THE UNIVERSITY OF TORONTO CAREER COUNSELLING AND PLACEMENT CENTRE

The Placement Centre, located at 581 Spadina Avenue, is open from 8:45 a.m., to 5 p.m., each week-day. The staff of the Centre maintain lists of part-time, permanent and summer employment opportunities in a wide variety of fields including the various branches of engineering. Engineering undergraduates are invited to drop in to discuss careers and employment problems.

Students looking for summer jobs should register at the Centre early in the academic term. This is important because job priorities are established on the basis of registration dates. Also, to be eligible for assistance under the Ontario Student Aid Plan, it is necessary for a student who has *not* obtained summer employment to have both registered at the Placement Centre and to have sought employment. The Centre will provide students who comply with these regulations with a letter for use with his O.S.A.P. application.

Early registration is also advisable for the fourth year permanent employment interviews which are organized by the Centre each year in the second week in December. Early registrants are given first choice of available interview times.

Students are given an opportunity to explore a variety of careers at a lecture and discussion series on "Careers in Industry, Government, and the Professions", presented by the Centre each year during the month of October. Watch the Varsity and Toike-Oike for specific career topics and dates.

IV

Fees, Deposits and Expenses

FEES

1. Undergraduate students in the Faculty of Applied Science and Engineering must pay annual fees according to the schedule listed below. The total fee in each case is made up of the academic fee and incidental fees; all incidental fees are payable in the first term.

Students will receive by mail in August a fees form and instructions for the payment of fees. In order to avoid delay in registration at the opening of the session it is recommended that at least the first term instalment of fees be forwarded by return mail before the end of August.

Fees may be paid by certified cheque, money order or personal cheque payable to the University of Toronto at par, and mailed to the Fees Department, University of Toronto, Toronto 181.

2. Payment of at least the First Term instalment must be made on or before the opening day of the session. An admit-to-lectures card cannot be issued until the student has complied with this requirement.

3. The Second Term instalment of fees, if not already paid, is due on the opening day of the second term and must be paid not later than January 15. After this date an additional fee of $3 per month or portion thereof (not exceeding $10), will be imposed until the whole amount is paid. All fees for the session must have been paid in full before the student can be admitted to the annual examinations.

4. Adjustment of fees for students who withdraw is made up to the twenty-fourth week of the session.

5. Fees, residence dues and other charges set forth in this calendar are subject to change by the Board of Governors.

SCHEDULE OF FEES

Men Academic Year	*Academic Fee	†Incidental Fees	Total Fee (if paid in one instalment)	First Term Instalment	Second Term Instalment
I–IV	$650	$67	$717	$392	$328

Women					
I–IV	$650	$39	$689	$364	$328

*The Academic Fee includes the following fees:
Tuition; Library and Laboratory Supply; one Annual Examination; Laboratory Fee; and Degree.

†These Incidental Fees include the following fees:
For men – Hart House; Students' Administrative Council; Athletic; Health Service; Engineering Society; Faculty Athletic Association.
For women – Students' Administrative Council; Athletic; Health Service; Engineering Society.

LATE REGISTRATION FEE

Any student who registers after the last date for normal registration in his or her own faculty or school is required to pay a late registration fee of $10 plus $1 for each day of delay to a maximum of $20.

EQUIVALENT CERTIFICATE FEE

Each student who has been admitted to the First Year upon a certificate or certificates granted outside the Province of Ontario and covering all or any part of the admission requirements, must pay a fee of $5.

ADVANCED STANDING FEE

Each student who has been admitted to advanced standing from another university or college, must pay a fee of $10.

SPECIAL STUDENTS FEES

The fee is $95 per subject, payable to the Fees Department.

SUMMARY OF STUDENTS' EXPENSES

The following approximate statement of expenses will give the student a general idea of the cost of obtaining an education in the Faculty of Applied Science and Engineering in the University of Toronto, exclusive of personal expenses:

1. Fees, see schedule page 17.	
2. Board and lodging, per week	$25 up
3. Books and instruments, per year	about $150
4. Miscellaneous personal expenses	$250 up

V

Programs and Degrees

UNDERGRADUATE PROGRAMS

The Faculty offers the following programs leading to the degree of Bachelor of Applied Science:

Civil Engineering (Program 1)
Mechanical Engineering (Program 3)
Industrial Engineering (Program 4)
Engineering Science (Program 5)
Chemical Engineering (Program 6)
Electrical Engineering (Program 7)
Metallurgy and Materials Science (Program 8)
Geological Engineering (Program 9)
Aerospace Engineering (offered as an option in Engineering Science. See page 63.)

The curricula of the various programs are set out in detail in Section VI. All programs require attendance for four academic sessions. Full-time attendance during the academic session is required, except in the case of students taking the First Year on a part-time basis through the Division of University Extension (see below).

FIRST YEAR — DIVISION OF UNIVERSITY EXTENSION

The First Year program (Division A only) is offered through the Division of University Extension for students interested in part-time evening study. Completion of this program qualifies the student for entry into the Second Year of all courses except Engineering Science. As there is no provision in the Division of University Extension for courses beyond the first-year level, students wishing to complete their studies for the degree must enter into full-time study in the regular courses in the Faculty of Applied Science and Engineering.

Information regarding the First Year Extension Program may be obtained from the Degree Courses Section, Division of University Extension, 84 Queen's Park, Toronto 181.

GRADUATE STUDY AND RESEARCH

Facilities are available in the Departments of the Faculty for postgraduate study an research leading to the degrees of Master of Engineering (M.Eng.), Master o Applied Science (M.A.Sc.), and Doctor of Philosophy (Ph.D.). For further information see the Calendar of the School of Graduate Studies.

SPECIAL STUDENTS

Graduates of the University of Toronto and of recognized universities who wish t take one or more undergraduate subjects may be registered as special students in th Faculty of Applied Science and Engineering, subject to the approval of the teachin department concerned. Application must be made to the Secretary of the Faculty

INTERIM HIGH SCHOOL ASSISTANT'S CERTIFICATE TYPE A

Graduate of engineering programs may be admitted to Type A certificate courses a the College of Education, University of Toronto, if they submit official transcripts which indicate that they have sufficient academic credits.

Graduates of engineering programs who lack sufficient academic credits for admission to Type A courses at the College of Education may be eligible for admission t the Type B course and later for endorsement of the Type B certificate.

Inquiries regarding admission to the Type B course should be addressed to th Registrar, the College of Education, University of Toronto. Inquiries regarding endorsement of Type B certificates or admission to Type A certificate courses should b addressed to the Director, Committee on Advanced Standing, the College of Education, University of Toronto.

ASSOCIATIONS OF PROFESSIONAL ENGINEERS

Graduation from the Faculty of Applied Science and Engineering leads to registration as a Professional Engineer in the various Associations of Professional Engineers throughout Canada.

VI Curriculum

In this era of rapid technological change, the professional role of engineering is to build bridges between the world of science and the world of men, and to do so with ingenuity, economy and sensitivity. The talent of the engineer is an amalgam of curiosity, physical insight, capacity for mathematical analysis, ability to work with people and to develop effective designs to achieve particular goals.

The early years of the four-year curriculum are designed to give students a command of the basic scientific principles upon which effective solutions to engineering problems are based. Although specialization into particular fields of study increases in the third and fourth years, the essential purpose of every academic program is to open the student's mind out to those general qualities which distinguish good engineering of any kind. These qualities transcend in importance the particular subject content in which they are projected.

On the following pages of this section the curriculum of each program is set forth in detail. As a guide to students in apportioning their time a weight factor is shown opposite each course of instruction. The weight factor represents the number of hours per week, including both scheduled class-room time and home work, that the average student is expected to devote to that course. This weight factor is also used in the computation of the student's weighted average in the work of the year.

The program and regulations regarding the courses of study and examination, contained in this Calendar, hold good for this academic year only, and the Faculty of Applied Science and Engineering does not bind itself to adhere for the whole period of a student's course to the conditions here laid down.

Communications relating to curricula, instruction, and examinations in the Faculty of Applied Science and Engineering should be sent to the Secretary of the Faculty.

For information regarding the courses of study leading to the post-graduate degrees, Master of Engineering, Master of Applied Science, and Doctor of Philosophy, see the calendar of the School of Graduate Studies, which gives full particulars.

First Year

Studies

Chairman For First Year Studies:

P. E. Burke, B.E. (N.S. TECH.), M.A.SC.

Coordinating Staff

V. C. Hamacher, B.A.SC.(WATERLOO), M.SC.(QUEEN'S), PH.D.(SYR.) Department of Electrical Engineering
H. R. MacCallum, M.A., PH.D. Department of English
R. A. Ross, M.A., PH.D. Department of Mathematics
S. Sandler, M.A.SC. Department of Chemical Engineering
G. T. Will, M.A.SC. Department of Civil Engineering
A. Straughen, B.SC.(LOND.) M.A.SC. Department of Electrical Eng.
G. D. Scott, M.A., PH.D. Department of Physics
I. W. Smith, M.A.SC. Department of Mechanical Engineering
C. A. Wrenshall, B.E. (SASK.) Department of Civil Engineering

FIRST YEAR STUDIES

The First Year program is designed to build a strong foundation in the basic disciplines which underlie the whole field of engineering. There are two First Year curricula — Division A, the standard curriculum and Division B, the enriched curriculum for students intending to pursue the Engineering Science program. Admission to the Division B curriculum is granted only to students with better-than-average ability in mathematics and the sciences. (See page 9 for admission requirements).

Students entering Division A must elect one of the following courses in which they expect to continue in second year — Civil Engineering, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Electrical Engineering, Metallurgy & Material Science, and Geological Engineering. Subject to the availability of places, a student who successfully completes the First Year in Division A may request to transfer to any other course within that Division.

Students who complete the First Year in Division B with a weighted average of 66% or higher may continue in the Engineering Science program in the second year. Those who achieve a weighted average between 60% and 66% may proceed to the second year of other programs in the Faculty, the choice of program being dependent on the availability of places. The First Year in Division B may not be repeated without the special permission of the Council of the Faculty.

Students wishing to transfer to a different program at the end of the first year should make application to the Secretary of the Faculty not later than July 15, 1970.

FIRST YEAR CURRICULUM — DIVISION A

Civil Engineering	Electrical Engineering
Mechanical Engineering	Metallurgy and Materials Science
Industrial Engineering	Geological Engineering
Chemical Engineering	

COURSES	COURSE NO.	HOURS PER WEEK First Term *Lect.*	*Lab.*	*Wt.*	Second Term *Lect.*	*Lab.*	*Wt.*
Chemistry	600, 601	2	3	7	2	3	7
Engineering Graphics	135	1	3	5	1	3	5
English*	2110	2	—	5	2	—	5
Mathematics:							
Algebra and Analytic Geometry	2410	2	1	6	2	1	6
Calculus	2411	2	1	6	2	1	6
Mathematical Applications and Computer Programming	13	½	2	3	½	2	3
Physics:							
Electricity	700	2	¾	5	2	¾	5
Applied Mechanics	100	2	¾	5	2	¾	5
Structure and Properties of Matter	2501	2	1½	6	2	1½	6
Engineering Design Project (optional)	11	—	—	—	—	—	1
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

FIRST YEAR CURRICULUM — DIVISION B
Engineering Science

COURSES	COURSE NO.	HOURS PER WEEK					
		First Term			*Second Term*		
		Lect.	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Chemistry	602, 601	2	3	7	2	3	7
Engineering Graphics	135	1	3	5	1	3	5
English*	2110	2	—	5	2	—	5
Mathematics:							
Algebra and Geometry	2415	2	3	7	2	3	7
Calculus	2416	2		7	2		7
Computer Programming	3310	—	—	—	1	1	4
Physics:							
Electricity	701	2	—	5	2	—	5
Statics	101	2	—	5	—	—	—
Elements of Physics I	2511,2512	2	2½	8	2	2½	8
Engineering Design Project (optional)	11	—	—	1	—	—	1

*or other non-technical elective. See page 63.

Civil Engineering

STAFF OF THE DEPARTMENT

Professor and Chairman of the Department:
T. C. Kenney, B.ENG.(MC.G.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.)

Associate Professor and Assistant Chairman of the Department:
S. M. Uzumeri, B.A.SC., M.A.SC.

Professors:
F. A. DeLory, B.ENG.(MC.G.), M.A.SC., D.I.C.(IMP.), PH.D.(LOND.) (*on leave for the session*)
C. Hershfield, B.SC., C.E.(MAN.), M.A.SC.
M. W. Huggins, B.A.SC., M.A.SC.
R. H. Mills, B.SC.(WITWATERSRAND)
H. R. Rice, B.SC.(QU.)
J. Schwaighofer, DIP. ING.(GRAZ.), M.S.(PENN. ST.), PH.D.(PENN. ST.), DR. TECH.(GRAZ.)

Associate Professors:
J. D. Barber, C.D., B.A.SC., M.A.SC.
A. P. Bernhart, DIP. ING.(GRAZ.), DR.TECH.(GRAZ.)
R. A. Collins, B.A.SC., M.S.(ILL.), PH.D.(ILL.)
A. C. Davidson, B.SC., C.E., B.SC., E.E.(MAN.), M.A.SC.
M. M. Davis, B.SC.(QU.), M.SC.(PURDUE)
H. R. Frizzle, B.SC., E.E.(N.S.TECH)
B. J. Haynes, B.A.SC.
G. W. Heinke, B.A.SC., M.A.SC., PH.D.(MCM.)
P. H. Jones, B.A.SC., M.S.(NORTHWEST.), PH.D.(NORTHWEST.)
H. L. Macklin, B.A.SC.
E. I. Robinsky, B.A.(BEIRUT), B.SC.(BEIRUT), M.S.(HARVARD), PH.D.
K. A. Selby, B.A.SC., M.B.A., PH.D.(ILL.)
J. Timusk, B.A.SC., M.A.SC., PH.D.(LOND.)
J. Vlcek, B.SC.F.(N.B.), M.A.SC., D.SC.(PRAGUE)
C. A. Wrenshall, B.E.(SASK.)

P. M. Wright, B.E.(SASK.), M.SC., PH.D.(COLORADO)
Visiting Associate Professor J. Ganczarzyk, M.SC., D.SC., DOC.(LABIL.)

Assistant Professors:
S. J. G. Bird, B.A.SC., M.A.SC.
M. P. Collins, B.E. (CANTERBURY), PH.D. (N.S.W.)
R. C. Gunn, B.A.SC., M.A.SC. (*on leave for the session*)
P. Lampert, DIP. ING.(S.F.I.T.), DR.SC. TECHN.(S.F.I.T.)
K. Meipoom, B.A.SC., M.A.SC.
V. R. Riley, B.A.SC., PH.D.(CANTAB.)
G. K. Rodgers, B.A.SC., M.SC.(U.B.C.), PH.D.
G. N. Steuart, B.SC.(SASK.), M.SC.(CALIF.), PH.D.
A. K. F. Turner, B.SC.(QU.), M.A.(COLUMBIA), PH.D.(PURDUE)
G. T. Will, B.A.SC., M.A.SC.

Lecturers:
V. P. Borecky, DIP. ING.(PRAGUE), M.A.
E. Karuks, B.A.SC., M.A.SC.
R. G. Rice, B.A.SC., M.SC(M.I.T.)

CIVIL ENGINEERING

Program 1

The program in Civil Engineering is broad and comprehensive. It is designed to produce an adequate basic understanding of the technical aspects of the principal fields (structural, municipal and sanitary, transportation, geotechnical surveying) in which Civil Engineers function with at least an acceptable level of competence in the activities (including executive and administrative) involved in each of those fields; and to provide for the acquisition, by the student, of superior competence in the particular field of his choice. To encourage a well-rounded education non-technical subjects and humanities are included. The objective of the program as a whole is the well-informed creative engineer possessing innovative and directive capabilities.

For the First Year curriculum see Division A, page 23.

SECOND YEAR CIVIL ENGINEERING

COURSES	COURSE NO.	HOURS PER WEEK					
		First Term			*Second Term*		
		Lect.	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Calculus	2420s	2	1	6	2	1	6
Economics*	2720	2	—	6	2	—	6
Engineering Materials	109s	2	—	5	2	3	7
Surveying	153	2	1½	6	1	1½	3
The Engineer and his Environment	137	1	3	6	1	3	6
Computer Programming	145	2	2	6	—	—	—
Engineering Presentation	138	1	3	5	—	—	—
Strength of Materials	110	3	—	7	—	—	—
Design of Structures	111	—	—	—	2	2	6
Engineering Mechanics	108	—	—	—	2	—	5
Environmental Engineering	180	—	—	—	2	—	4
Geology	2900	—	—	—	2	2	6
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

THIRD YEAR CIVIL ENGINEERING

COURSES	COURSE NO.	HOURS PER WEEK					
		First Term			*Second Term*		
		Lect.	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Design of Determinate and Indeterminate Structures	112	2	2	7	3	2	10
Fluid Mechanics and Hydraulics	333	2	—	5	2	3	8
Soil Mechanics and Foundations	191	2	1½	6	2	1½	7
History*	2330	2	—	6	2	—	6
Engineering Mathematics	142	3	2	9	—	—	—
Probability and Statistics	141	2	—	6	—	—	—
Transportation Systems	185	3	2	9	—	—	—
Municipal Engineering	182	—	—	—	2	2	7
Elective (see p. 29)		—	—	—	3	2	9
Survey Camp	158						
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

FOURTH YEAR CIVIL ENGINEERING

COURSES	COURSE NO.	First Term Lect.	First Term Lab.	First Term Wt.	Second Term Lect.	Second Term Lab.	Second Term Wt.
Thesis†	40	—	—	9	—	—	12
Administration and Management	133	2	—	6	—	—	—
English*	2140	2	—	6	—	—	—
Elective		3	2	9	—	—	—
Elective		3	2	9	—	—	—
Elective		3	2	9	—	—	—
Elective†		3	2	9	—	—	—
Public Speaking	132	—	—	—	—	2	3
Philosophy and Science*	2040	—	—	—	2	—	6
Elective		—	—	—	3	2	9
Elective		—	—	—	3	2	9
Elective		—	—	—	3	2	9

*or other non-technical elective. See page 63.

†If a 21 unit thesis is elected, only three elective courses are required in fall term.

ELECTIVE COURSES

Each student is advised to consult with a member of the staff in establishing the electives that the student will include in his program. A student is free to choose his elective courses from those listed below, each of which will have a weight of 9 units. In some cases, depending upon student interest and staff availability, one or more electives may be offered in both terms, or not at all.

First Term Electives

105	Advanced Strength of Materials
114	Advanced Engineering Materials
116	Reinforced Concrete I
119	Indeterminate Structures
170	Photogrammetry and Remote Sensing
183	Pollution Control Engineering
187	Traffic Engineering
189	Air Photo Interpretation
193	Foundations and Earth Work
345s	Water Resources and Hydrology

Second Term Electives

117	Reinforced Concrete II (Prerequisite: 116 Reinforced Concrete I)
118	Behaviour and Design of Steel Structures
120	Construction Engineering*
167	Engineering Applications of Surveying*
168	Geodetic Control Surveys
188	Transportation Engineering
194s	Engineering Geology
343s	Hydraulic Engineering
3540s	Urban and Regional Planning*

With the approval of the Chairman of the Department a student may include, as part of his required elective program, courses that are offered outside the Department provided that the University Department, Faculty or Institute offering the courses has agreed to accept him for those courses.

*available to Third and Fourth Year students.

Mechanical Engineering

STAFF OF THE DEPARTMENT

Professor and Head of the Department:
G. R. Lord, B.A.SC., S.M.(M.I.T.), PH.D.

Professors:
W. D. Baines, B.SC.(ALTA.), M.S., PH.D.(IOWA)
F. C. Hooper, B.A.SC., D.I.C.(LOND.)
P. B. Hughes, B.SC.(MCG.)
L. E. Jones, B.SC.(C.E.) (MAN.), M.A.SC., PH.D.
F. P. J. Rimrott, DIP. ING.(KARLSRUHE), M.A.SC., PH.D.(PENN. STATE), DR. ING.(DARMSTADT)
I. W. Smith, M.A.SC.

Associate Professors:
A. B. Allan, M.A.SC.
I. G. Currie, B.SC.(STRATHCLYDE), M.A.SC.(B.C.), PH.D.(CAL.I.T.)
R. C. Fenton, DIP. ING.(BUD.), PH.D.(N.S.W.)
J. F. Keffer, M.A.SC., PH.D.
V. Klemes, DIP. ING.(BRNO), C.SC.(BRATISLAVA)
H. J. Leutheusser, DIP. ING.(KARLSRUHE), M.A.SC., PH.D.
D. S. Scott, B.SC.(QUEEN'S), M.SC.(QUEEN'S), PH.D.(NORTHWESTERN)
J. VandeVegte, DIP. ING.(DELFT), M.A.SC., PH.D.

Assistant Professors:
A. H. Abdelmessih, B.M.E.(CAIRO), M.S.(OKLAHOMA STATE), PH.D.
D. L. Allen, B.SC.(DAL.), B.E.(N.S. TECH.), M.A.SC., PH.D.
J. S. Ansari, B.E.(OSMANIA), M.S.(PURDUE), PH.D.(PURDUE)
J. P. Dugan, B.SC.(PENN. MIL. COLL.), M.S.(NORTHWEST.), PH.D.(NORTHWEST.)
R. C. Flanagan, B.SC.(N.B.), PH.D.(B.C.)
G. E. Godfrey, M.A.SC.
D. F. James, B.SC.(QUEEN'S), M.S.(CAL. TECH.), PH.D.(CAL. TECH.)
D. McCammond, B.SC.(QU. BELFAST), PH.D.(QU. BELFAST)
P. S. Shen, B.SC.(LOND.), M.SC.(BIRMINGHAM), PH.D.(LOND.)

B. Tabarrok, B.SC.(WOLVER. & STAFF.), D.PHIL.(OXON)
C. A. Ward, B.SC.(TEX.), PH.D.(NORTHWEST.)

Special Lecturer:
F. E. Burke, B.A.(LOND.).

MECHANICAL ENGINEERING

Program 3

Traditionally associated with the art and science of power generation and the machines and devices by which power is usefully applied and controlled, Mechanical Engineering, like other branches of the engineering profession, participates actively in the advancement of knowledge and interprets this knowledge in the design and development of practical systems.

In manufacturing industry, in the transportation and power utilities, in the high-performance field of air and space engineering, or in engineering aspects of major works and structures, the mechanical engineer finds professional occupation, either as employee or consultant. His responsibility will generally be for the superintendence of operations and personnel, for the design of products and processes, and may include the administration of enterprises.

The curriculum in Mechanical Engineering provides an analytical training in mathematics and the physical sciences designed as a disciplinary basis for active professional practice. Recognition is given, however, to the purer scientific and philosophical concepts essential to postgraduate study and research.

For the First Year curriculum see Division A, page 23.

SECOND YEAR MECHANICAL ENGINEERING

COURSES	COURSE NO.	HOURS PER WEEK *First Term* *Lect.*	*Lab.*	*Wt.*	*Second Term* *Lect.*	*Lab.*	*Wt.*
Economics*	2720	2	—	7	2	—	7
Calculus	2424	3	1½	10	—	—	—
Circuit Theory & Measurements	717	3	3	10	—	—	—
Dynamics	351	3	1½	10	—	—	—
Mechanics of Materials	107	3	3	11	—	—	—
Differential Equations	380	—	—	—	2	—	6
Design of Machine Elements	356	—	—	—	2	3	8
Materials Science	837	—	—	—	3	1½	9
Probability and Statistics	2422	—	—	—	3	1½	10
Theory of Machines	358	—	—	—	2	3	8
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

THIRD YEAR MECHANICAL ENGINEERING

COURSES		HOURS PER WEEK					
	COURSE	*First Term*			*Second Term*		
	NO.	*Lect.*	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt*
Dynamic Measurement Laboratory	362	—	3	4	—	3	3
Engineering Mathematics I	386	3	1	8	—	—	—
Engineering Mathematics II	387	—	—	—	3	1	8
Fluid Mechanics I	334	2	—	4	2	3	8
Heat Engineering Laboratory I	310	—	3	3	—	3	4
Systems Dynamics	360	1	—	2	1	—	2
Engineering Thermodynamics	309	2	—	4	2	—	4
History*	2330	2	—	6	2	—	6
Electronics	743	2	3	7	—	—	—
Heat Engineering	308	2	—	4	—	—	—
Vibrations	361	2	—	4	—	—	—
Electric Machines	747	—	—	—	2	3	7
Engineering Design	363, 364	—	—	—	2	3	8
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

FOURTH YEAR MECHANICAL ENGINEERING

Applied Fluid Mechanics	344	2	1½	6	2	1½	6
Applied Mechanics	367	2	1½	6	2	1½	6
Control Systems	391, 392	2	1½	6	2	1½	6
Heat Transfer	319	2	1½	6	2	1½	6
Thesis	40	—	3	6	—	3	4
Engineering Law	3440	1	—	1	—	—	—
English*	2140	2	—	6	—	—	—
Philosophy and Science*	2040	—	—	—	2	—	6
Numerical Analysis	2443	—	—	—	2	—	4
And two of:							
Engineering Mathematics III	390	2	—	4½	2	1½	6
Fluid Mechanics II	346	2	—	4½	2	1½	6
Manufacturing Science	374	2	—	4½	—	—	—
Design Methodology	375	—	—	—	2	1½	6
Microscopic Thermodynamics	322	2	—	4½	2	1½	6
Thermal Power Generation	323	2	—	4½	2	1½	6

*or other non-technical elective. See page 63.

Industrial Engineering

STAFF OF THE DEPARTMENT

Professor and Chairman of the Department:
B. Bernholtz, M.A., PH.D.(CAL. TECH.)

Associate Professor and Assistant Department Chairman:
R. W. P. Anderson, M.A.SC.

Professors:
J. W. Abrams, A.B.(CALIF.), PH.D.(CALIF.)
P. J. Foley, M.A.(GLASGOW)
A. Porter, M.SC.(MANCH.), PH.D.(MANCH.) (*on leave for the session*)

Associate Professors:
J. Abrham, M.A.(CHARLES), PH.D.(CHARLES)
S. H. Cohn, M.A.
T. A. Lambe, B.A.SC.(U.B.C.), M.SC.(STAN.), PH.D.(STAN.)
J. G. C. Templeton, B.A., A.M.(PRINC.), PH.D.(PRINC.)

Assistant Professors:
J. A. Buzacott, B.SC.(SYDNEY), B.E.(SYDNEY), M.SC.(BIRMINGHAM), PH.D.(BIRMINGHAM)
A. A. Cunningham, M.A.(OXFORD), PH.D.(ADELAIDE)
M. J. M. Posner, B.A.SC., PH.D.
I. B. Turksen, B.S.(PITTS.), M.S.(PITTS.), PH.D.(PITTS.)
E. L. Vitalis, B.B.A.(MINN.), M.A.(MINN.)

Lecturers (part-time)
A. K. Mackworth, B.A.SC., M.A.(HARVARD)
E. E. Pickett, B.A.SC., M.A.
A. L. Saipe, B.A.SC., M.A.SC.

Special Lecturers (part-time):
J. M. Tusiewicz, B.SC.(ENG.)(LOND.), M.A.SC., M.B.A.
J. Vanderheyden, B.A.SC.
Mrs. J. L. Vitalis, B.A.(MINN.)

INDUSTRIAL ENGINEERING

Program 4

The modern view of Industrial Engineering is that of a field concerned with the analysis, design improvement and operation of integrated systems of men, materials and equipment. This concept crystallized when it became clear that certain modern technical fields, including operational research, control theory, computer science, probability and statistics, systems theory and human factors engineering, constituted a body of knowledge particularly useful in the operation and management of modern business, industry and government.

As a logical outcome of this development, the course in Industrial Engineering was established in 1958 to provide graduates in engineering specializing in the theory and practice of these subjects. This specialization rests upon a substantial foundation in science and mathematics, in fundamental engineering disciplines including fluid mechanics, applied thermodynamics, electric science, mechanics of materials, materials science and automation, and in such subjects as economics, organizational structure, financial control and the behavioural sciences.

For the First Year curriculum see Division A, page 23.

SECOND YEAR INDUSTRIAL ENGINEERING

COURSES	COURSE NO.	HOURS PER WEEK First Term Lect.	Lab.	Wt.	Second Term Lect.	Lab.	Wt.
Calculus	2420	2	1	9	2	1	9
Elements of Industrial Engineering	414	2	—	5	2	—	6
Economics*	2720	2	—	6	2	—	6
Probability and Statistics I	2423	2	2	9	2	2	9
Computers and Programming I	422	2	2	9	—	—	—
Materials Science	834	3	3	9	—	—	—
Electrical Engineering	722	—	—	—	3	3	9
Mechanics of Materials	102, 104	—	—	—	2	3	8
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

THIRD YEAR INDUSTRIAL ENGINEERING

Accounting	2734	2	—	8	2	—	8
History*	2330	2	—	6	2	—	6
Operational Research	424	2	2	8	2	2	8
Computers and Programming II	423	2	2	8	—	—	—

COURSES	COURSE	HOURS PER WEEK					
		First Term			*Second Term*		
	NO.	*Lect.*	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Numerical Analysis I	2433	2	2	8	—	—	—
Control Engineering	394	—	—	—	2	2	8
Industrial Engineering Seminar	462	—	—	—	—	2	2
Probability and Statistics II	2430	—	—	—	2	2	8
Practical Experience	20	—	—	—	—	—	—
and one subject from each of Groups 1 and 2							
Group 1							
Differential Equations	2432	2	2	8	—	—	—
Industrial Relations	463	2	1	8	—	—	—
Group 2							
Fluid Mechanics & Thermodynamics	337	—	—	—	2	3	8
Numerical Analysis II	2434	—	—	—	2	2	8

*or other non-technical elective. See page 63.

FOURTH YEAR INDUSTRIAL ENGINEERING

Engineering Law	3440	1	—	2	—	—	—
English*	2140	2	—	6	—	—	—
Philosophy and Science*	2040	—	—	—	2	—	6
Industrial Engineering Seminar	471	—	2	2	—	—	—
Thesis	421	—	3	6	—	3	8
and 1 subject from each of Groups 1 & 2							
Group 1							
Man as a Machine	427	2	—	8	—	—	—
Differential Psychology	426	2	—	8	—	—	—
Group 2							
Man as an Information Processor	425	—	—	—	2	—	8
Organizational Psychology	428	—	—	—	2	—	8

*or other non-technical elective. See page 63.

FOURTH YEAR INDUSTRIAL ENGINEERING

COURSES	COURSE NO.	HOURS PER WEEK First Term *Lect.*	 *Lab.*	 *Wt.*	 Second Term *Lect.*	 *Lab.*	 *Wt.*
and a selection of at least 24 units (3 subjects in each term) from the following:							
Control of Processes	415	2	1½	8	2	1½	8
Management Science	418	2	1½	8	2	1½	8
Production Systems	477	2	1½	8	—	—	—
Stochastic Models	476	2	1½	8	—	—	—
System Simulation	429	2	1½	8	—	—	—
Advanced Industrial Engineering	478	—	—	—	2	1½	8
Information and Optimization	430	—	—	—	2	1½	8
Management Information Systems	488	—	—	—	2	1½	8
Mathematical Programming	483	—	—	—	2	1½	8
Technical Elective	—	—	—	8	—	—	8

Engineering Science

FACULTY MEMBERS OF THE DIVISION

Chairman of the Division:

B. Etkin, M.A.SC., F.R.S.C., F.C.A.S.I. (Professor of Aerospace Engineering)

Members of the Division:

K. T. Aust, M.A.SC., PH.D. (Professor of Metallurgy and Materials Science)

P. P. Biringer, DIP. ING(BUD.), M.SC.(STOCKHOLM), PH.D. (Professor of Electrical Engineering)

G. F. D. Duff, M.A., PH.D., F.R.S.C. (Professor and Chairman of the Department of Mathematics)

W. F. Graydon, M.A.SC., PH.D.(MINN.), (Professor and Chairman of Chemical Engineering)

J. N. P. Hume, M.A., PH.D. (Professor of Physics and Computer Science)

R. L. Armstrong, M.A., PH.D. (Professor of Physics)

J. VandeVegte, DIP. ING.(DELFT), M.A.SC., PH.D. (Professor of Mechanical Engineering)

ENGINEERING SCIENCE

Program 5

The Engineering Science program is designed for students whose primary interest is in the applications of science to modern technology, and who wish to prepare themselves for careers in research, development or teaching. The undergraduate course provides excellent preparation for post-graduate work in a wide range of specialities in Engineering, Science and Mathematics, and the majority of graduates from this course do proceed to graduate study. Students who graduate from the course and do not continue their studies are nevertheless well qualified to fill a variety of positions in Industry and Government.

The courses offered are of a high standard, so that only students with better-than-average ability in, and aptitude for, mathematics and science can expect to succeed in them. For this reason, admission is granted only to those who attain an average of at least 70% in the Ontario Grade XIII or its equivalent (see p. 9). The First Year of the Course may not be repeated without the special permission of the Council of the Faculty, and continuation into the second year is restricted to those whose weighted average grade in first year is 66% or higher. Those who achieve the general promotion average of 60% in the first year may continue without condition into the second year of the Faculty, the choice of program being subject to the availability of places.

The curricula for the first two years of the course are common for all students In the third and fourth years, there are a few common subjects, and considerable latitude in the selection of the remainder. There are available eight carefully planned *options,*† each of which provides a specialized preparation for a particular branch of applied science. In addition students have the opportunity not to enroll in any one of these options, but to take an *elective program,* as outlined below.

For the First Year curriculum see Division B, page 24.

SECOND YEAR ENGINEERING SCIENCE

COURSES	COURSE NO.	HOURS PER WEEK *First Term* *Lect.*	*Lab.*	*Wt.*	*Second Term* *Lect.*	*Lab.*	*Wt.*
Calculus	2425	3	2	9	3	2	9
Economics*	2720	2	—	6	2	—	6
Electrical Circuits	715	2	1½	7	2	1½	7
Elements of Physics II	2521,2522	3	1½	8½	3	1½	8½
Physical Chemistry	608,609	2	1½	6	2	1½	6
Mechanics of Materials	103	2	—	4	—	—	—
Probability & Statistics	2427	3	2	9	—	—	—
Computer Languages	3320	—	—	—	2	—	6
Numerical Methods	2429	—	—	—	2	2	7

*or other non-technical elective. See page 63.

Each student will be asked to indicate before the end of Second Year his intended course of study in Third Year. This information is for Faculty planning only, and is not binding on the student.

Students may elect

(a) to enrol in one of the 8 options listed, in which case up to three elective substitutions of subjects are permitted, or

(b) to select a program that does not conform to any one of the options.

In case (a), substitutions must be on a basis of roughly equal weights, so that the modified program has approximately the same weight as the standard option. In case (b) the weight shall average approximately 48 units for the two terms. In both cases, the selection of electives is subject to the constraints imposed by the current timetable, and by prerequisites. Electives may be chosen from among the subjects offered to other options in Engineering Science; from among the subjects listed in this Calendar

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†For further information about the Aerospace Option, see page 61.

that are offered in programs other than Engineering Science; or, with the approval of the offering department, from subjects offered in other Faculties.

IN ALL CASES, ELECTIVE CHOICES (other than those explicitly provided for within options) MUST BE APPROVED BY A MEMBER OF THE DIVISION STAFF.

THIRD YEAR ENGINEERING SCIENCE

	HOURS PER WEEK						
COURSES	COURSE	*First Term*			*Second Term*		
	NO.	*Lect.*	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
COMMON SUBJECTS:							
Differential Equations	2438	2	—	5	2	—	5
Theory of Functions	2437	2	—	5	2	—	5
History*	2330	2	—	6	2	—	6
OPTION 5A, *Aerospace*							
Mechanics	1030	2	—	5	2	—	5
Quantum Physics	2533	2	—	5	2	—	5
Electronics	740	2	—	5	2	1½	7
Mechanics of Structures	1034, 1035	2	1½	6	2	3	8
Fluid Mechanics	1028, 1029	2	3	8	1	1½	4
Physics Laboratory	2540 or 2541	—	3	3	—	—	—
Statistical Physics	2531	—	—	—	2	—	5
OPTION 5C, *Chemical*							
Atomic & Molecular Struct.	2631	2	—	4	2	—	4
Chem Eng Problems & Lab	642	—	9	10	—	6	6
Chem Eng Thermodynamics	640	2	—	4	2	—	4
Electronics	740	2	—	5	2	1½	7
Synthetic Chemistry	626	2	—	4	2	—	4
Fluid Mechanics	338	2	3	6	—	—	—
Chem Eng Rate Processes	641	—	—	—	3	1½	8
OPTION 5CS, *Computer Science*							
Electronics	740	2	—	5	2	1½	7
Physical Electronics	739	2	1	6	2	1	6
Quantum Physics	2533	2	—	5	2	—	5
Computer Organization	3341	2	2	7	—	—	—
Switching Theory	760	2	1	7	—	—	—
Programming & Data Struct.	3338	—	—	—	3	6	14
Statistical Physics	2531	—	—	—	2	—	5

*or other non-technical elective. See page 63.

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

COURSES	COURSE	HOURS PER WEEK					
		First Term			*Second Term*		
	NO.	*Lect.*	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
OPTION 5E, *Electrical*							
Mechanics	1030	2	—	5	2	—	5
Physical Electronics	739	2	1	6	2	1	6
Quantum Physics	2533	2	—	5	2	—	5
Electromagnetic Fields	754	2	2	7	—	—	—
Physics Laboratory	2540 or 2541	—	3	3	—	—	—
System & Signal Analysis	744	2	1½	6	—	—	—
Electronic Circuits I	737	—	—	—	2	3	9½
Physics of Solids & Fluids	2534	—	—	—	2	—	5
Statistical Physics	2531	—	—	—	2	—	5
OPTION 5G, *Geophysics*							
Electronics	740	2	—	5	2	1½	7
Mechanics	1030	2	—	5	2	—	5
Physics Laboratory	2538 or 2539	—	3	3	—	3	3
Principles of Geology	2920	2	2	7	2	2	7
Quantum Physics	2533	2	—	5	2	—	5
Geophysics	2537	2	—	5	—	—	—
Physics of Solids & Fluids	2534	—	—	—	2	—	5
Statistical Physics	2531	—	—	—	2	—	5
OPTION 5M, *Materials Science*							
Materials Science	838	2	—	5	2	—	5
Metallurgical Thermodynamics	830	2	2	7	2	2	7
Physical Metallurgy Laboratory	822	—	3	3	—	3	3
X-ray Crystallography	2901	—	2	3	—	2	3
Physics Laboratory	2540	—	3	3	—	—	—
Solid State Science	820	2	—	5	—	—	—
Physics of Solids & Fluids	2534	—	—	—	2	—	5
Plastic Deformation and Mechanical Properties	821	—	—	—	2	—	5
and *one* of:							
Chemical Bonding	634	2	—	5	2	—	5
Mechanics	1030	2	—	5	2	—	5
Physical Electronics	739	2	1½	7	2	1½	7
OPTION 5NT, *Nuclear & Thermal Power*							
Experimental Stress Analysis	365	2	—	5	1	3	5
Fluid Mechanics	340	2	3	8	2	3	8

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

COURSES		HOURS PER WEEK					
	COURSE	*First Term*			*Second Term*		
	NO.	*Lect.*	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Heat Engineering	313	1	3	5	1	3	5
Mechanics	1030	2	—	5	2	—	5
Physics Laboratory	2538 or 2539	—	3	3	—	3	3
Quantum Physics	2533	2	—	5	2	—	5
Statistical Thermodynamics	303	—	—	—	2	—	5
OPTION 5P, *Physics*							
Mechanics	1030	2	—	5	2	—	5
Physical Electronics	739	2	1	6	2	1	6
Physics Laboratory	2538 or 2539	—	3	3	—	3	3
Quantum Physics	2533	2	—	5	2	—	5
Electromagnetic Fields	754	2	2	7	—	—	—
Physics of Solids & Fluids	2534	—	—	—	2	—	5
Statistical Physics	2531	—	—	—	2	—	5
And *one* of:							
Electronic Circuits	740	2	—	5	2	1½	7
Experimental Stress Analysis	365	2	—	5	1	3	5

FOURTH YEAR ENGINEERING SCIENCE

COMMON SUBJECTS:							
Differential Equations of Mathematical Physics	2445	2	—	5	2	—	5
English*	2140	2	—	6	—	—	—
Philosophy*	2040	—	—	—	2	—	6
OPTION 5A, *Aerospace*							
Aerodynamics	1040,1041	2	1½	6	2	1½	6
Engineering Design	1047	—	6	8	—	3	4
Gasdynamics	1048,1049	2	1½	6	2	3	8
Thesis	40	—	—	6	—	—	4
Transport Phenomena	1050	—	—	—	2	—	4
And *two* of:							
Electronic Circuits, and	778	2	3	8	—	—	—
Electrodynamics	797	—	—	—	2	1½	7
Physics & Mechanics of Solids	1044 1045	2	1½	6	2	1½	6
Physics of Radiating Gases	1042 1043	2	1½	6	2	1½	6

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*or other non-technical elective. See page 63.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

COURSES	HOURS PER WEEK						
	COURSE NO.	*First Term*			*Second Term*		
		Lect.	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Plasmadynamics	1046	2	—	6	2	—	6
Control Systems	398, 399	2	—	5	1	3	5½
OPTION 5C, *Chemical*							
Chem. Eng. Design	666	2	6	9	2	6	9
Mass Transfer	650	2	—	4	2	—	4
Organic Chemistry	660, 661	2	—	5	1	6	7
Process Dynamics	664	2	—	5	2	3	7
Thesis	40	—	—	2½	—	—	7½
Chem. Eng. Laboratory	652	—	9	9	—	—	—
Thermodynamics of Chem. Systems	665	3	—	7½	—	—	—
Dynamics of Chem. Systems	667	—	—	—	3	—	7½
OPTION 5CS, *Computer Science*							
Thesis	40	—	—	6	—	—	4
Computer Organization	3341	2	2	7	—	—	—
Electronic Circuits	778	2	3	8	—	—	—
Information Systems I	782	2	1	6	—	—	—
Numerical Solution of Initial Value Problems	2441	2	—	6	—	—	—
Theory of Computability	3342	2	—	5	—	—	—
Automata Theory	3343	—	—	—	2	—	6
Operating Systems	3344	—	—	—	2	—	5
Numerical Solution of Boundary Value Problems	2442	—	—	—	2	—	6
Switching Circuits	799	—	—	—	2	1½	7
Techniques of Optimization	787	—	—	—	3	2	10
OPTION 5E, *Electrical*							
Quantum Theory	2545	2	—	7	2	—	7
System Dynamics	766	2	1½	6½	—	—	—
Thesis	40	—	—	5	—	—	5
Electronic Circuits	778	2	3	8	—	—	—
Information Systems I	782	2	1	6	—	—	—
Wave Theory	790	2	1½	6½	—	—	—
Information Systems II	786	—	—	—	2	3	8
Switching Circuits	799	—	—	—	2	1½	7

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

COURSES	COURSE NO.	HOURS PER WEEK First Term Lect.	Lab.	Wt.	Second Term Lect.	Lab.	Wt.
And one of the following:							
Electrodynamics	797	—	—	—	2	1½	7
Introduction to Optimal Control	767	—	—	—	2	—	7
Techniques of Optimization	787	—	—	—	3	2	10
OPTION 5G, *Geophysics*							
Control Systems	398, 399	2	—	5	1	3	5½
Geophysics Laboratory	2573	—	9	9	—	9	9
Geophysical Methods	2561	2	—	7	2	—	7
Physics of the Earth	2570	2	—	7	2	—	7
Thesis	40	—	—	5	—	—	5
And *one* of:							
Atmospheric Physics	2571	2	—	7	2	—	7
Classical Physics of Continua	2560	2	—	7	2	—	7
OPTION 5M, *Materials Science*							
High Temperature Physical Chemistry	842	2	3	8	2	3	8
Materials Science	839	2	3	8	2	3	8
Thesis	40	—	—	3	—	—	7
Physics of Metals	823	3	—	6	—	—	—
Theory of Metallurgical Reactions	841	2	—	6	—	—	—
Materials Science Lab.	827	—	—	—	—	6	8
And *one* of:							
Quantum Theory	2545	2	—	7	2	—	7
Solid State Physics	2546	2	—	7	2	—	7
OPTION 5NT, *Nuclear and Thermal Power*							
Control Systems	398, 399	2	—	5	1	3	5½
Nuclear Engineering	670, 671	2	3	8	2	3	8
Nuclear Physics	2544	2	—	7	2	—	7
Thermal Energy Conversion	331	3	3	9	3	3	9
Thesis	40	—	—	4	—	—	6
Physics Seminar	2550	2	—	7	—	—	—
Heat Transfer	328	—	—	—	2	—	5

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

COURSES	COURSE NO.	First Term Lect.	First Term Lab.	First Term Wt.	Second Term Lect.	Second Term Lab.	Second Term Wt.
OPTION 5P, *Physics*							

Each student shall select a program that includes the common subjects, a thesis, and subjects chosen from groups A and B below to a total of approximately 48 units (averaged over both terms). At least 12 units (total for two terms) must be chosen from group A.

COURSES	COURSE NO.	First Term Lect.	First Term Lab.	First Term Wt.	Second Term Lect.	Second Term Lab.	Second Term Wt.
Thesis	40	—	—	5	—	—	5
	GROUP A						
Plasmadynamics	1046	2	—	6	2	—	6
System Dynamics	766	2	1½	6½	—	—	—
Electronic Circuits	778	2	3	8	—	—	—
Wave Theory	790	2	1½	6½	—	—	—
Electrodynamics	797	—	—	—	2	1½	7
	GROUP B						
Nuclear Physics	2544	2	—	7	2	—	7
Physics Seminar	2542	2	—	7	2	—	7
Quantum Theory	2545	2	—	7	2	—	7
Relativity Theory	2547	2	—	7	2	—	7
Solid State Physics	2546	2	—	7	2	—	7
Statistical Mechanics	2543	2	—	7	2	—	7
Interaction of Radiation and Matter	2553	2	—	7	—	—	—
Molecular Biophysics	2559	2	—	7	—	—	—
Molecular Physics	2555	2	—	7	—	—	—
Nuclear & Particle Physics	2557	2	—	7	—	—	—
Statistical Mechanics	2558	2	—	7	—	—	—
Cellular Biophysics	2548	—	—	—	2	—	7
High Energy Physics	2552	—	—	—	2	—	7
Magnetic Resonance	2554	—	—	—	2	—	7
Quantum Optics	2551	—	—	—	2	—	7
Solid State Physics	2556	—	—	—	2	—	7

Chemical Engineering and Applied Chemistry

STAFF OF THE DEPARTMENT

Professor and Chairman of the Department:

W. F. Graydon, M.A.SC., PH.D.(MINN.)

Associate Professor and Assistant Head of the Department:

J. W. Smith, M.A.SC.(U.B.C.), PH.D.(LOND.)

Professors:

D. G. Andrews, M.A.(CANTAB.) (*Nuclear Engineering*)
J. G. Breckenridge, B.A.SC., PH.D.(CANTAB.)
W. H. Burgess, B.CH.E., M.F.S., PH.D.(CORN.)
R. E. Jervis, M.A., PH.D.
W. G. MacElhinney, M.A.SC.
R. W. Missen, M.SC.(QU.), PH.D.(CANTAB.)
W. H. Rapson, M.A.SC., PH.D.
I. H. Spinner, M.A.SC., PH.D.
O. Trass, B.S.E.(PRINC.), SC.D.(M.I.T.)
M. Wayman, M.A., PH.D.
H. L. Williams, B.A., M.SC.(WESTERN), PH.D.(MCGILL)

Associate Professors:

D. Basmadjian, DIP. ING. CHEM.(ZURICH), M.A.SC., PH.D.
M. E. Charles, B.SC.(LOND.), M.SC., PH.D.(ALTA.)
W. A. M. Hewer, B.A.SC. (*Mining Engineering*)
R. L. Hummel, B.S.(PURDUE), PH.D.(IOWA)
R. F. Hunter, M.A.SC., PH.D.
R. Luus, M.A.SC., A.M., PH.D. (PRINCETON)
M. R. Piggott, M.SC., PH.D.(LOND.) (*Materials Science*)
S. Sandler, M.A.SC.
R. T. Woodhams, M.SC.(U.W.O.), PH.D.(BROOKLYN) (*Materials Science*)

Assistant Professors:
D. Barham, B.SC.ENG., D.I.C., PH.D.(LOND.)
C. E. Chaffey, B.SC., PH.D.(MCGILL) (*Materials Science*)
J. S. Hewitt, B.SC.(QU.), M.S., PH.D.(BIRM.) (*Applied Nuclear Studies*)
D. Mackay, B.SC., PH.D. (GLASGOW)
C. R. Phillips, B.E., PH.D.(ADELAIDE)
V. R. Riley, B.A.SC., PH.D.(CANTAB.) (*Materials Science*)
P. Y-C. Wang, B.SC., PH.D.(MCGILL) (*Biomedical Electronics*)

Lecturers:
C. C. Barnes, B.SC.(QU.)
J. Binkiewicz, DIP. CHEM. ENG.(LWOW)
Z. May, DIP. ING. CHEM.(WARSAW)
Miss M. J. Phillips, B.A.SC., M.A.(BRYN MAWR), PH.D.(J.H.U.)
A. Rozeiu, DIP. CHEM. ENG.(BUCHAREST)
R. B. Thompson, B.A.SC.

Special Lecturer:
C. P. Brockett, B.SC.(M.I.T.)

CHEMICAL ENGINEERING

Program 6

The chemical engineer is concerned with the development and operation of processes by means of which matter is chemically altered to a more useful form, and in the design, construction, operation and management of plant in which to effect such changes. In addition to such obviously chemical processes as those encountered in the petroleum refining and petro-chemical industry, a great variety of industrial processes involve chemistry and require the abilities of the chemical engineer. In order to equip a student to start his professional career as a chemical engineer, the undergraduate course is intended to provide him with training in the principles of the major divisions of chemistry and chemical engineering, together with the essentials of other engineering subjects.

In the second term of the final year, certain elective subjects and the topic chosen for the thesis allow the student to specialize according to his interests and abilities. The thesis serves as an introduction to research, and its nature may vary widely depending on the interests of the staff and students. It may, for example, be concerned with an experimental laboratory investigation, the design of a process, or a computer study of a chemical system.

For the First Year curriculum see Division A, page 23.

SECOND YEAR CHEMICAL ENGINEERING

COURSES	COURSE NO.	First Term Lect.	First Term Lab.	First Term Wt.	Second Term Lect.	Second Term Lab.	Second Term Wt.
Analytical Chemistry Laboratory	613	—	—	—	—	—	—
Calculus	2420	2	1	6	2	1	6
Economics*	2720	2	—	6	2	—	6
Electrical Engineering	719	2	3	7	2	3	7
Inorganic Chemistry	617	1	—	2	2	—	4
Mass and Heat Transfer	631	2	—	4	2	—	4
Mechanics of Materials	102	2	—	4	2	—	4
Physical Chemistry	622	2	—	4	2	—	4
Process Calculations	620	—	3	3	—	3	3
Analytical Chemistry	615, 614	2	9	12	—	—	—
Chemical Engineering Science Lab	619	—	—	—	—	8	8
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

THIRD YEAR CHEMICAL ENGINEERING

COURSES	COURSE NO.	First Term Lect.	First Term Lab.	First Term Wt.	Second Term Lect.	Second Term Lab.	Second Term Wt.
Applied Mathematics	633	1	1	3	1	1	3
Chemical Engineering Thermodynamics	640	2	2	6	2	2	6
Chemical Laboratory	627	—	6	6	—	6	6
Fluid Mechanics	339, 632	2	3	7	2	—	4
History*	2330	2	—	6	2	—	6
Industrial Chemistry	630	2	—	4	1	—	2
Mass Transfer Operations	650	2	1	5	2	1	5
Organic Chemistry	628	2	—	4	2	—	4
Organic Chemistry Lab	629	—	6	6	—	9	9
Practical Experience	20	—	—	—	—	—	—
Reaction Kinetics	625	1	—	2	1	—	2
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

FOURTH YEAR CHEMICAL ENGINEERING

COURSES	COURSE	HOURS PER WEEK					
		First Term			*Second Term*		
	NO.	*Lect.*	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Thesis	40	—	1	2	—	18	21
Chemical Engineering Laboratory	652	—	9	12	—	—	—
English*	2140	2	—	6	—	—	—
Philosophy and Science*	2040	—	—	—	2	—	6
Public Speaking	656	—	—	—	—	2	2
and one course from each of the following seven groups:**							
I Chemical Engineering Thermodynamics	655	2	—	6	—	—	—
Interface Kinetics	684						
Molecular Thermodynamics	672						
II Plant Design	651	2	3	9	—	—	—
Process Modelling and Simulation	653						
Strategy of Process Engineering	673						
III Advanced Separation Processes	669	2	—	6	—	—	—
Convective Heat Transfer	675						
Pipeline Transportation	674						
IV Composite Materials	678	2	—	6	—	—	—
Polymer Engineering	676						
Wood Chemistry	677						
V Applied Nuclear Chemistry	668	—	—	—	2	—	6
Ceramics	679						
Co-ordination Chemistry	680						
VI Environmental Engineering	681	—	—	—	2	—	6
Instrumental Methods	663						
VII Chemical Bonding	682	—	—	—	2	—	6
Nuclear Engineering	683						
Process Control	662						

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*or other non-technical elective. See page 63.

**In any one session, it may not be possible to offer all the elective courses.

Electrical Engineering

STAFF OF THE DEPARTMENT

Professor and Head of the Department:
G. R. Slemon, M.A.SC., D.I.C.(IMP. COLL.), PH.D.(LOND.), D.SC.(LOND.)

Professor and Associate Head of the Department:
H. W. Smith, B.A.SC., SC.D.(M.I.T.)

Professors:
P. P. Biringer, DIP. ING.(BUD.), M.SC.(STOCKHOLM), PH.D.
R. S. C. Cobbold, B.SC.(LOND.), M.SC.(SASK.), PH.D.(SASK.)
J. M. Ham, B.A.SC., S.M.(M.I.T.), SC.D.(M.I.T.)
W. Janischewskyj, M.A.SC.
N. F. Moody, B.SC.(SASK.)
E. E. Newhall, B.SC.(ALTA.), M.SC., PH.D.
J. G. Simmons, B.SC.(LOND.), M.SC.(TEMPLE), PH.D.(LOND.), F.INST.P.
G. Sinclair, B.SC.(ALTA.), M.SC.(ALTA.), PH.D.(OHIO STATE)
J. L. Yen, B.SC.(CHIAO TUNG), M.A.SC., PH.D.

Associate Professors:
K. G. Balmain, B.A.SC., M.S.(ILL.), PH.D.(ILL.)
P. I. P. Boulton, M.A.SC., PH.D.
P. E. Burke, B.E.(N.S. TECH.), M.A.SC.
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S. Dmitrevsky, B.A.SC., PH.D.(HARV.)
V. L. Henderson, B.A.SC., A.M.(MICH.)
K. Iizuka, B.S.(KYOTO), M.E.(KYOTO), M.S.(HARV.), PH.D. (HARV.)
A. J. Kravetz, B.SC.(ALTA.), M.A.SC.
G. R. Lang, B.SC.(U.W.O.)
E. S. Lee, B.ENG.(MCG.), M.ENG.(MCG.), PH.D.
I. McCausland, B.SC.(Q.U. BELFAST), M.SC.(Q.U. BELFAST), PH.D.(TOR., CANTAB.)
H. O'Beirne, B.A.(CAMB.), M.A.SC.

S. D. T. Robertson, B.SC.(QUEEN'S), D.I.C.(IMP. COLL.), M.A.SC., PH.D.
I. H. Rowe, M.A.SC., D.I.C.(IMP. COLL.), PH.D.(LOND.)
C. A. T. Salama, M.A.SC.(U.B.C.), PH.D.(U.B.C.)
R. S. Segsworth, B.A.SC.
K. C. Smith, M.A.SC., PH.D.
A. Straughen, B.SC.(LOND.), M.A.SC.
E. Llewellyn Thomas, B.SC.(LOND.), M.D., C.M.(MCG.)

Visiting Associate Professor:
A. Semlyen, D.ENG.(RUM.), PH.D.(RUM.)

Assistant Professors:
L. D. Braun, B.A.SC., M.A.SC., PH.D.
M. G. Currie, B.A.SC.
S. B. Dewan, B.SC.(PUNJAB), M.E.(ROORKEE), M.A.SC., PH.D.
V. C. Hamacher, B.A.SC.(WATERLOO), M.SC.(QUEEN'S), PH.D.(SYR.)
M. G. Joy, B.A.SC., M.A.SC., PH.D.
H. Kunov, M.SC.(DENMARK)
V. M. Ristic, DIP. ING.(BELGRADE), M.SC.(BELGRADE), M.SC.(STAN.), PH.D.(STAN.)
A. S. Sedra, B.SC.(CAIRO), M.A.SC., PH.D.
M. Sablatash, B.SC.(MAN.), M.SC.(MAN.), PH.D.(WIS.)
A. N. Venetsanopoulos, B.E.(ATHENS), M.A.SC.(YALE), PHIL.M.(YALE), PH.D.(YALE)
Z. G. Vranesic, B.A.SC., M.A.SC., PH.D.
S. Zukotynski, M.A.SC.(WARSAW), PH.D.(WARSAW)

Special Lecturers:
M. A. Albisser, M.A.SC., PH.D.
D. J. Shepley, M.D., B.A.SC.

ELECTRICAL ENGINEERING

Program 7

Electrical Engineers are concerned with all things electrical; but such a simple statement fails to convey any real notion of the great variety of activity in which they are engaged, the many aspects of their concern, or the nature of the education that they require.

Electrical engineers are, of course, still involved in the application of new knowledge to the basic areas — the generation, transmission and utilization of electrical power and the communication of information—but they are being faced daily with situations not envisaged even a few years ago. They are searching continuously for new approaches that may be better suited to future needs, as for example, magneto-hydrodynamic generation, microelectronics and satellite communication. There is a growing demand for sophisticated electrical sensing and control equipment for a wide variety of non-electrical processes, and for electronic computers capable of the rapid processing of large volumes of information and the solving of increasingly complex problems.

Within any of these areas the electrical engineer may be engaged in research, development, design, manufacture, operation or management. He may have to assist other engineers and scientists in widely differing fields by supplying them with techniques or insights unfamiliar to them, as for example, in the developing field of bio-medical engineering, or he may have to coordinate the application of many technologies in a single project. In addition to all of this, he must accept considerable responsibility in community affairs.

It is obvious then, from the wide range of his possible involvement, that the electrical engineer needs a professional education of great breadth and depth. In the undergraduate course, stress is laid on building a solid foundation. The time limitation requires that only material which is essential can be included; much that might be immediately helpful must be omitted to make room for that which will still be relevant for several years. On this base, the graduate will have to build his continuing education.

The electrical engineer makes extensive use of mathematical techniques and concepts; mathematics is thus of the utmost importance and a large portion of the course is devoted to it. Fundamental subjects such as mechanics, electrical physics, chemistry and thermodynamics get considerable attention in the early years. The basic electrical engineering subjects (electromagnetic field theory, electronics, machine principles and circuit theory) follow these, with expansion and some specialization in the final year. Also included are a few non-technical subjects of importance. In the final year, only one-third of the curriculum is prescribed by the department; students freely select the rest of their curriculum from a wide range of elective subjects.

Electrical engineering is characterized by the relatively large proportion of its graduates who proceed to post-graduate study to get advanced training in a particular area. Information on this may be obtained from the calendar and other publications of the School of Graduate Studies.

For the First Year curriculum see Division A, page 23.

SECOND YEAR ELECTRICAL ENGINEERING

COURSES	COURSE NO.	HOURS PER WEEK					
		First Term			*Second Term*		
		Lect.	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Calculus II	2421	4	2	11	—	—	—
Circuit Theory I	710	3	2	9	—	—	—
Materials Science I	819	3	1½	9	—	—	—
Electrical Laboratory	713	—	3	4	—	—	—
Dynamics	352	3	2	9	—	—	—
Numerical Methods	721	—	—	—	2	2	7
Circuit Theory II	712	—	—	—	2	2	7
Thermodynamics & Statistical Mechanics	751	—	—	—	3	1	9
Introductory Electronics	714	—	—	—	2	3	9½
Electric & Magnetic Fields	711	—	—	—	3	2	9½
Economics*	2720	2	—	6	2	—	6
Practical Experience	20	—	—	—	—	—	—

THIRD YEAR ELECTRICAL ENGINEERING

Applied Mathematics I	732	2	2	7	—	—	—
Linear Systems Theory	733	4	2	12	—	—	—
Physical Electronics I	730	2	1½	8	—	—	—
Fields and Waves	750	2	2	7	—	—	—
Electromechanical Systems I	734	2	3	8	—	—	—
Applied Mathematics II	736	—	—	—	3	2	9½
Materials Science II	835	—	—	—	2	1½	7½
Physical Electronics II	731	—	—	—	2	1½	7½
Electronic Circuits I	737	—	—	—	2	3	9½
Electromechanical Systems II	735	—	—	—	2	3	8
History*	2330	2	—	6	2	—	6
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

FOURTH YEAR ELECTRICAL ENGINEERING

			HOURS PER WEEK					
COURSES	COURSE		*First Term*			*Second Term*		
	NO.		*Lect.*	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Control Systems I	765		3	1½	9	—	—	—
Electronic Circuits II	768		2	3	8	—	—	—
Thesis	40		—	—	4	—	—	7
English*	2140		2	—	6	—	—	—
Philosophy*	2040		—	—	—	2	—	6
ELECTIVES – *3 to be chosen first term:*†								
Applied Mathematics III	781		2	1	7	—	—	—
Electromagnetic Theory	762		2	1	7	—	—	—
Information Processing Systems I	761		2	1	7	—	—	—
Network Theory	772		2	1	7	—	—	—
Power System Analysis	779	⎫	2	1½	7	—	—	—
Quantum Physics	777	⎭	2	1½	7	—	—	—
Semiconductor Physics	775		2	1½	7	—	—	—
Switching Theory	760		2	1	7	—	—	—
Other Technical Elective			2	1½	7	—	—	—
ELECTIVES – *5 to be chosen second term:*†								
Illumination	794	⎫	—	—	—	2	1½	7
Quantum Electronics (777 prerequisite)	784	⎭	—	—	—	2	1	7
Power System Control	780	⎫	—	—	—	2	1½	7
Radiation and Propagation (762 prerequisite)	776	⎭	—	—	—	2	1½	7
Acoustics	792		—	—	—	2	1½	7
Biomedical Engineering	796		—	—	—	2	1½	7
Communication Systems	770		—	—	—	2	3	7
Control Systems II	793		—	—	—	2	1½	7
Electrodynamics (762 prereq.)	797	⎫	—	—	—	2	1½	7
Power Semiconductor Circuits	795	⎭	—	—	—	2	1½	7
Information Processing Systems II (761 prereq.)	798		—	—	—	2	1	7
Integrated Circuits	774	⎫	—	—	—	2	1½	7
Unified Machine Theory	763	⎭	—	—	—	2	1½	7
Switching Circuits	799		—	—	—	2	1½	7
Other Technical Elective			—	—	—	2	1½	7

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*or other non-technical elective. See page 63.

†Bracketed subjects can not be taken together.

Metallurgy and Materials Science

STAFF OF THE DEPARTMENT

Professor and Chairman of the Department:
C. B. Alcock, B.SC., PH.D., A.R.C.S., D.SC.(LOND.), F.R.I.C., M.I.M.M.

Professors:
K. T. Aust, M.A.SC., PH.D.
G. B. Craig, M.A.SC., PH.D.
S. N. Flengas, B.SC.(ATHENS), D.I.C.(LOND.), PH.D., D.SC.(LOND.), F.C.I.C.
H. U. Ross, C.D., M.SC.(MCG.)
J. W. Rutter, M.A., PH.D.
J. M. Toguri, M.A.SC., PH.D.

Associate Professors:
Mrs. U. Martius Franklin, PH.D.(BERLIN)
B. Ramaswami, B.SC., D.I.I.SC., M.A., PH.D.(HARVARD)
R. S. Segsworth, B.A.SC.

Assistant Professors:
W. A. Miller, PH.D.(MCG.)
G. C. Weatherly, PH.D.(CANTAB.)

Special Lecturer:
L. M. Pidgeon, M.B.E., B.SC.(OXON.), PH.D.(MCG.), F.R.S.C.

METALLURGY AND MATERIALS SCIENCE

Program 8

"Metallurgy and Materials Science" is the study of the production, structure, and properties of the engineering materials used in structures, machines and devices.

Modern technology makes increasingly severe demands upon both metallic and non-metallic solids; in fact, it is difficult to think of an engineering project, the basic limitations of which do not reside in the materials which are available. For example, aerospace travel requires materials capable of withstanding extremes of heat, cold and pressure; the utilization of nuclear energy is limited only by materials which can withstand the effects of radiation; the transistor and the computer depend upon materials having special electrical and magnetic properties. As industry expands, the metallurgist or materials engineer is being called upon to play an increasingly important role in the economy.

The course is designed to place primary emphasis upon the fundamental principles which underlie the chemical, physical and mechanical properties of solids. In the fourth year, each student is assigned an experimental problem involving original work and, where possible, this is related to the actual research in progress in the department. The student is, therefore, introduced to the methods of research.

The department is equipped with modern facilities for the study of the structure and properties of materials. This equipment includes x-ray diffraction units, an electron beam microprobe analyzer, an electron microscope, several optical metallographs, materials preparation and testing equipment, facilities for the production and measurement of high temperatures, high vacuum equipment, etc.

For the First Year curriculum see Division A, page 23.

SECOND YEAR METALLURGY AND MATERIALS SCIENCE

COURSES	COURSE	HOURS PER WEEK					
		First Term			*Second Term*		
	NO.	*Lect.*	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Calculus	2420	2	1	8	2	1	8
Mechanics of Materials	104, 106	2	—	5	1	1½	5
Economics*	2720	2	—	6	2	—	6
Physical Chemistry	801	2	2	7	2	4	9
Probability and Statistics	2423	2	2	8	2	2	8
Solid State Chemistry	807	2	2	7	—	—	—
Structure of Materials & Metallography	817	2	3	8	—	—	—
Instrumental Analysis	808	—	—	—	—	3	4
Materials Science	832S	—	—	—	3	—	7
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

THIRD YEAR METALLURGY AND MATERIALS SCIENCE

COURSES	COURSE	HOURS PER WEEK					
		First Term			*Second Term*		
	NO.	*Lect.*	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Extractive Metallurgy	802, 803	2	3	7	2	3	7
Fluid Flow and Heat Transfer	341	2	—	5	2	3	7
History*	2330	2	—	6	2	—	6
Physical Metallurgy Laboratory	822	—	3	3	—	3	3
Thermodynamics	810, 812	2	4	7	2	2	6
X-ray Crystallography	2901	—	2	3	—	2	3
Differential Equations	2432	2	2	7	—	—	—
Solid State Science	820	2	—	5	—	—	—
Numerical Analysis	2443	—	—	—	2	—	5
Plastic Deformation & Mechanical Props.	821	—	—	—	2	—	5
Technical Electives – 1 to be chosen in each term:							
Polymer Engineering	676	2	—	5	—	—	—
Physical Electronics I	730	2	¾	6	—	—	—
Materials Science Laboratory	825	—	3	5	—	—	—
Applied Nuclear Chemistry	668	—	—	—	2	—	5
Nuclear Engineering	683	—	—	—	2	—	5
Mineral Dressing	809	—	—	—	2	—	5
Extractive Metallurgy Project	829	—	—	—	—	3	5
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

FOURTH YEAR METALLURGY AND MATERIALS SCIENCE

COURSES	COURSE	HOURS PER WEEK					
		First Term			*Second Term*		
	NO.	*Lect.*	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Extractive Metallurgy	805, 806	2	3	7	2	3	7
Metallurgical Problems Laboratory	814	—	3	4	—	3	4
Thesis	40, 840	—	6	7	—	9	12
Electrical Systems	764	2	—	5	—	—	—
Physics of Metals	823, 824	3	3	9	—	—	—
Reaction Kinetics	836	2	2	6	—	—	—

FOURTH YEAR METALLURGY AND MATERIALS SCIENCE (CONTINUED)

COURSES	COURSE NO.	HOURS PER WEEK *First Term* *Lect.*	*Lab.*	*Wt.*	*Second Term* *Lect.*	*Lab.*	*Wt.*
English*	2140	2	—	6	—	—	—
Philosophy*	2040	—	—	—	2	—	6
Electro-chemical Processes	813	—	—	—	2	2	6
Materials Science	815	—	—	—	3	—	7
Technical Electives – 1 to be chosen in each term:							
Composite Materials	678	2	—	5	—	—	—
Manufacturing Science	374	2	—	5	—	—	—
Ceramics	679	—	—	—	2	—	5
Powder Metallurgy	826	—	—	—	2	—	5
Physical Metallurgy Project	828	—	—	—	—	3	5

*or other non-technical elective. See page 63.

Geological Engineering

The course in Geological Engineering is an interfaculty course, the specialized core of which is provided by the Department of Geology (Faculty of Arts and Science) with assistance from several departments of the Faculty of Applied Science and Engineering. It is administered by a Course Committee the current members of which are:

E. W. Nuffield, B.A.(B.C.), PH.D., F.R.S.C., *Chairman; Professor and Chairman, Department of Geology.*

W. D. Baines, B.SC.(ALTA), M.SC., PH.D.(IOWA); *Professor of Mechanical Engineering.*

J. G. Breckenridge, B.A.SC., PH.D.(CANTAB.), *Professor of Chemical Engineering.*

J. B. Currie, B.A.(MCM.), M.A., PH.D., *Professor of Geology.*

T. C. Kenney, B.ENG.(MCG.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.), *Professor and Chairman, Department of Civil Engineering.*

H. R. Rice, B.SC.(QUEEN'S), *Professor of Mining Engineering.*

GEOLOGICAL ENGINEERING

Program 9

Geology is the science of the earth. It includes, in a large sense, all knowledge of the earth – its origin, history, structure, composition and mineral wealth – and the physical, chemical and biological processes that change the earth. It spans a wide range of sciences and requires a thorough grounding in mathematics and the basic science and engineering disciplines to aid in a proper understanding of the subject and its many applications. The various branches of geology include geophysics, which is concerned with the investigation of the earth, particularly its structure and composition, by the methods of experimental physics; geochemistry, which may be defined broadly to include all parts of geology that involve chemical changes; and geobiology which deals with the totality of living things on the earth's surface in geologic time.

The first three years of the course in Geological Engineering provide a broad education in the fundamentals of geology and its associated disciplines. In the fourth year the course concentrates on the study of Economic Geology – the application of principles and methods of geology in the discovery, examination, evaluation and production of mineral, fossil fuel and water resources. Several options in the final year allow the student to shape his program to emphasize the study of Exploration Geology, Mining, or Soil Mechanics.

Graduation from this course leads to employment in mineral and petroleum exploration and development. Graduates are prepared for advanced study towards the M.A.Sc. and Ph.D. degrees in a number of branches of geology including Economic Geology, Geochemistry, Structural Geology and Applied Geophysics.

For the First Year curriculum see Division A, page 23.

SECOND YEAR GEOLOGICAL ENGINEERING

	HOURS PER WEEK						
COURSES	COURSE	*First Term*			*Second Term*		
	NO.	*Lect.*	*Lab.*	*Wt.*	*Lect.*	*Lab.*	*Wt.*
Calculus	2420	2	1	6	2	1	6
Economics*	2720	2	—	6	2	—	6
Geological Data Processing by Computer	2922	1	2	5	1	2	5
Inorganic Chemistry	617	1	—	3	2	—	6
Mineralogy	2921	2	4	10	2	4	10
Mining	195	1	—	3	1	2	5
Principles of Geology	2920	2	3	8	2	3	8
Surveying	155, 156	1	1½	5	1	1½	5
Practical Experience	20	—	—	—	—	—	—

*or other non-technical elective. See page 63.

THIRD YEAR GEOLOGICAL ENGINEERING

COURSES	COURSE NO.	HOURS PER WEEK *First Term* *Lect.*	 *Lab.*	 *Wt.*	 *Second Term* *Lect.*	 *Lab.*	 *Wt*
Geological Field Trips	2937	—	—	—	—	—	—
Mechanics of Materials	104, 106	2	—	5	1	1½	5
Extractive Metallurgy	805	2	—	5	2	—	5
Mineral Identification Laboratory	2934	—	2	2	—	2	2
Petrology	2930	2	2	6	2	2	6
Physical Geochemistry	2935	3	—	6	3	—	6
Practical Experience	20	—	—	—	—	—	—
Stratigraphy and Sedimentation	2931	2	2	6	2	2	6
Tectonics	2932	1	3	6	1	3	6
History*	2330	2	—	6	2	—	6
Survey Camp	158	—	—	—	—	—	—
One of:							
Differential Equations	2432	2	1½	5	2	1½	5
Mining Technology	196	2	—	4	2	—	4
Air Photo Interpretation	189	3	2	5	—	—	—

FOURTH YEAR GEOLOGICAL ENGINEERING

English*	2140	2	—	6	—	—	—
Philosophy*	2040	—	—	—	2	—	6
Geological Field Trips	2947	—	—	—	—	—	—
Geology Field Camp	2946	—	—	3	—	—	3
Mineral Deposits	2940	2	3	9	2	3	9
Mineral Exploration	2944	—	—	—	—	3	3
Petroleum and Groundwater Geology	2941	2	3	9	2	3	9
Thesis	40	—	3	4	—	3	4
And two of:							
Exploration Geochemistry	2943	1	3	7	1	3	7
Exploration Geophysics	2568,2569	2	3	9	2	3	9
Mining	197, 198	2	3	8	2	3	8
Soil Mechanics	191	2	1½	8	2	1½	8

*or other non-technical elective.

Aerospace Studies

TEACHING STAFF OF THE INSTITUTE FOR AEROSPACE STUDIES

Professor and Director of the Institute:

G. N. Patterson, B.SC.(ALTA.), M.A., PH.D., LL.D., D.SC., F.R.AE.S., F.C.A.S.I., F.A.I.A.A., F.R.S.C., F.A.A.A.S.

Professors and Assistant Directors:

J. H. deLeew, DIP. ING.(DELFT), M.S. in A.E.(GEORGIA TECH.), PH.D., F.C.A.S.I. (*Assistant Director – Research.*)

I. I. Glass, B.A.SC., M.A.SC., PH.D., F.A.P.S., F.A.A.A.S., F.C.A.S.I. (*Assistant Director – Education*).

Professors:

B. Etkin, B.A.SC., M.A.SC., F.C.A.S.I., F.R.S.C.

J. B. French, B.A.SC., M.SC.(BIRMINGHAM), PH.D.

H. S. Ribner, B.S.(CAL. TECH.), M.S.(WASH.). PH.D.(WASH.), F.A.P.S., F.A.S.A., F.C.A.S.I.

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G. K. Korbacher, DIP. ING.(BERLIN), PH.D.(BRAUNSCHWEIG)

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R. C. Tennyson, B.A.SC., M.A.SC., PH.D.

S. J. Townsend, B.A.(SASK.), M.A.(SASK.), PH.D.

Assistant Professors:

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J. W. Locke, B.A.SC., M.A.SC.

L. D. Reid, B.A.SC., M.A.SC.

P. A. Sullivan, B.E., M.E.(N.S.W.), D.I.C., PH.D.(LOND.)

AEROSPACE STUDIES

The University of Toronto offers a broad and coherent program of studies in the aerospace sciences and engineering. It is designed to prepare its graduates for work in a variety of areas including civil air transportation, design and development of new aircraft, spacecraft and air cushion vehicles, and fundamental research in man of the relevant underlying areas of science. Future Canadian needs for air and su face transportation, satellite communications, and survey satellites are significar factors in determining the content of the courses and the research projects unde taken.

The courses of study available comprise a basic 4 year program leading to th B.A.Sc. degree, an additional year leading to the M.Eng. or M.A.Sc. degree, and subsequent Doctoral program. The undergraduate (Bachelor's) program consists c four years in Engineering Science (option 5a), and the post-graduate programs ar taken in the department of Aerospace Studies of the School of Graduate Studies.

(i) *Undergraduate Program.* The details of the undergraduate program are given i this Calendar (page 37) and are seen to consist mainly of intensive studies in th fundamentals of mathematics, physics, and the engineering sciences. In the final tw years the program is oriented to the special needs of the aerospace field, and ir cludes some highly specialized courses. The aerospace-related subjects in these tw years are taught by the faculty of the Institute for Aerospace Studies. Graduates c this program are able to fill a variety of positions in education, industry and goverr ment, but the fifth year (see below) is needed to become fully qualified as an aerc space engineer.

(ii) *Graduate Program.* If the student's academic record in the undergraduate prc gram meets the requirements for admission to the School of Graduate Studies, h may pursue during a fifth year a program as a candidate for the M.A.Sc. or M.Eng degree in the (graduate) department of Aerospace Studies. Details of entrance regulations and courses of study are given in the Calendar of the School of Graduat Studies. The facilities of the Institute for Aerospace Studies are available to th student for research or project work. For details of research fields, assistantships scholarships and demonstratorships, students should consult the secretary of th graduate department.

It should be noted that a student who has graduated in another branch of engineering, or in science or mathematics, and who desires to qualify as an aerospac engineer may be admitted to the graduate program. In that case the courses leadin to the M.A.Sc. or M.Eng. degree will be arranged on an individual basis so that an deficiencies in undergraduate training are made up.

The facilities of the Institute are available for further graduate study and researc leading to the Ph.D. degree.

Outline of Lecture and Laboratory Subjects

On the pages that follow a brief description is given of the lectures and laboratory subjects prescribed in the preceding tables of curriculum. The numbers before the subjects are the reference numbers assigned in the tables; the line following each subject title shows the academic year and course to which the subject is offered and the hours allotted to it in each term.

Where laboratory reports are to be written outside of assigned laboratory hours the maximum number of such reports is indicated in the description of the laboratory course concerned.

NON-TECHNICAL ELECTIVES

Each student must include in his annual program a humanities course having a weight equivalent to two hours lectures per week. The humanities courses listed in this calendar (I English 2110, II Economics 2420, III History of Technology and Engineering 2330, IV English 2140 and Philosophy and Science 2040, the latter two being half-courses) are offered expressly for students of this Faculty. The work-load of these courses is commensurate with the time available to engineering students, and the lectures and examinations are scheduled so as to avoid conflict with the engineering program.

Students who wish to have a broader choice of study in the area of the humanities and social sciences may elect, in place of any of the courses mentioned above, appropriate courses offered in the Faculty of Arts and Science. A list of acceptable courses may be obtained from the Secretary of the Faculty of Applied Science and Engineering.

Students who elect a humanities course in the Faculty of Arts and Science should bear in mind that the work load involved is likely to be somewhat heavier than that required by one of the regular humanities courses offered in the Faculty of Applied Science and Engineering. Some courses, especially language courses, have laboratory or tutorial requirements, and most courses involve substantial reading and essay assignments. In some cases, conflicts in the final examinations can not be avoided, and the student may have to write two examinations on a particular day.

INTERDEPARTMENTAL COURSES

11s. INTRODUCTION TO ENGINEERING AND DESIGN

I – 1, 3, 4, 5, 6, 7, 8, 9

This is an elective course which students may take in addition to the regular first-year program. As well as providing an introduction to the engineering approach to problem solving and decision making, using actual engineering problems, the course offers a valuable contact between first-year students and the faculty staff. Students who take the course will receive credit for it, and the results will be included in the computation of the student's average in the work of the year.

After two general lectures on engineering, students will form groups numbering about six and will meet from time to time with a Faculty Supervisor to carry out a design or research project. Topics may be selected from those proposed by students, faculty or industry.

The Professorial Staff in Engineering

13s. MATHEMATICAL APPLICATIONS AND COMPUTER PROGRAMMING

I – 1, 3, 4, 6, 7, 8, 9 ½ 2 ½ 2

Problems will be assigned to illustrate engineering applications of mathematics. Many of the solutions will apply first-year mathematics to solve problems in Applied Mechanics, Chemistry or Electricity. The concepts of algorithms, stored programs and computer coding will be introduced; some of the more time-consuming numerical and non-numerical applications will be solved with the aid of a computer.

The Staff in Engineering

20. PRACTICAL EXPERIENCE

Students in the courses listed below are required to have, before graduation, practical work of a nature acceptable to the department concerned. This may be obtained during the summer vacations but work done before entering the Faculty may also meet the requirements. Instructions will be issued by the departments concerning the type of work which is acceptable. Practical experience certificate forms may be obtained from the departments and should be returned there when completed.

Course 1	600 hours	Course 7	600 hours
Course 3	600 hours	Course 8	600 hours
Course 4	600 hours	Course 9	600 hours
Course 6	600 hours		

40. THESIS

Every student in the Fourth Year is required to prepare a thesis on an approved subject. Instruction will be issued by the department concerned.

In some cases written presentation is required, in other oral and written, or it may consist of a research problem followed by a written thesis or report

DEPARTMENT OF CIVIL ENGINEERING

100s. APPLIED MECHANICS

I – 1, 3, 4, 6, 7, 8, 9 2 ¾ 2 ¾

Statics: The principles of statics are applied to the composition and resolution of forces, moments and couples. The equilibrium states of frames and machines are examined. The distributed load concept is applied to finding centroids, centers of mass and fluid pressure. The method of virtual work is applied to systems of rigid bodies and elastic members. Dynamics: Applications of the principles of dynamics are discussed for motion on straight and curved paths. Work, energy, power and momentum concepts are applied to particles, systems of particles and rigid bodies. Simpler applications in relative motion are considered. Throughout statics and dynamics the free body concept is emphasized and vector algebra is used where it is most useful. Textbook: Vector Mechanics for Engineers – Beer and Johnston.

G. T. Will and Staff in Civil and Mechanical Engineering

101. STATICS

I – 5 2 – – –

Translational and rotational resultants and equilibrants are discussed together with equivalent force systems in two- and three-dimensional space. Emphasis is placed on systems in equilibrium. Distributed forces, applications to structures, friction, method of virtual work, potential energy and stability of equilibrium considered. Textbook: *Engineering Mechanics; Statics* – Huang.

S. M. Uzumeri, M. P. Collins

102. MECHANICS OF MATERIALS

II – 4 – – 2 –
II – 6 2 – 2 –

In this subject, the fundamental theories of stress and strain are investigated as they apply to the selection of adequately proportioned materials to carry a given load in such engineering applications as tension, compression torsional, and other members. Textbook: *Engineering Mechanics of Deformable Bodies* – Byars and Snyder.

J. D. Barber, V. R. Riley, J. Timusk

103. MECHANICS OF MATERIALS

II – 5 2 – – –

Basis relationships between force, stress, strain, and deflection of bodies made of various engineering materials are discussed. Beams, columns, shafts, tension members and pressure vessels are analysed and designed for strength and stiffness. Textbook: *Mechanics of Materials* – Popov.

E. Karuks

104. MECHANICS OF MATERIALS LABORATORY

II – 3 – 3 – –
II – 4 – – –
II – 8, III – 9 – – – 1½

An introduction to testing machines, strain and other measuring devices and standard specifications. The experimental study of some engineering materials and structura members under applied load. No laboratory reports will be required to be written outside the assigned teaching hours.

105. ADVANCED STRENGTH OF MATERIALS

IV – 1 (elective) 3 2 – –

To be considered are advanced topics in bending including the analysis of curved and deep beams, analysis of cable systems, columns and beam-columns. In addition the theory of elasticity will be introduced including basic concepts related to plates and shells.

R. A. Collins

106. MECHANICS OF MATERIALS

II – 8, III – 9 2 – 1 –

The fundamental relations among stress, strain and applied load are worked out for tension, compression, twisting and bending in the elastic and inelastic ranges, for various engineering materials. Buckling phenomena are examined for struts and columns. Numerical applications are done in lectures; and problems are assigned for study. Textbook: *Engineering Mechanics of Deformable Bodies* – Byars and Snyder.

A. C. Davidson

107. MECHANICS OF MATERIALS

II – 3 3 – – –

In this subject the following are examined: behavior of materials under applied loading or deformation; stress-strain relations; simple tension, compression torsion, bending and buckling of engineering components; mechanical properties of materials such as ductility, yielding, fracture; fluctuating stresses, stress concentration and fatigue. Mohr's circle will be used in certain stress and certain strain relationships. Textbook: *Engineering Mechanics of Deformable Bodies* – Byars and Snyder.

A. C. Davidson

108. ENGINEERING MECHANICS

II – 1 – – 2 –

Topics to be considered include rigid body dynamics, energy principles applied to statics problems, virtual work, strain energy and an introduction to vibration.

K. A. Selby

109s. ENGINEERING MATERIALS

II – 1 2– 2 3

Mechanical properties of materials on atomic as well as macroscopic levels. The topics covered include atomic bonding, structure of crystals, phase transformations and diffusion, mechanical properties of materials and corrosion phenomena. Thermodynamics of adsorptions, freezing mechanisms in porous materials, surface phenomena, colloidal suspensions, gels and pastes, concrete, wood, bituminous materials, polymers, composite materials and the selection of materials for specific applications. The laboratory program deals with materials on a macroscopic level.

J. Timusk and Staff in Materials Science

110. STRENGTH OF MATERIALS

II – 1 3 – – –

An introduction to the elastic and inelastic behaviour of solids under various load conditions. Stress, strain and deformation relations are determined for members loaded axially, in torsion, in bending and compression.

J. D. Barber

111. DESIGN OF STRUCTURES

II – 1 – – 2 2

In this subject the total design process involved in achieving any final structure will be introduced. The application of these procedures to determinate structural systems will be presented through the design of several such structures. The principal engineering materials, reinforced concrete, steel, and timber will be treated.

P. M. Wright

112. DESIGN OF DETERMINATE AND INDETERMINATE STRUCTURES

III – 1 2 2 3 2

A continuation of the subject Design of Structures with emphasis on more complex determinate systems.

The analysis of simple indeterminate structural systems is examined. At the same time, design aspects of these systems in reinforced concrete and in steel will be considered.

J. Schwaighofer

114. ADVANCED ENGINEERING MATERIALS

IV – 1 (elective) 3 2 – –

A continuation of Course 109s with an emphasis on the practical design and selection aspects, emphasizing a detailed comparative study of such materials as steel, concrete, timber, masonry materials, bitumens, insulating materials subjected to different types of loading: various temperatures, corrosive environments. Relationship between materials and methods of construction. Laboratory work to complement the above.

R. H. Mills

116. REINFORCED CONCRETE I

IV – 1 (elective) 3 2 – –

Ultimate and working strength behaviour of reinforced concrete members subjected to flexure, axial compression, shear, combined axial compression and flexure, combined flexure and shear, and bond. Relation between research results and current specifications for design of members. Design of simple and continuous beams, one way, two way and flat slabs, columns, retaining walls and footings. Reference books: *Reinforced Concrete Fundamentals* – Ferguson. *Design of Reinforced Concrete Structures* (Seventh Edition) – Winter, Urquhart, O'Rourke, Nilson.

M. P. Collins

117. REINFORCED CONCRETE II

IV – 1 (elective) – – 3 2

Prestressed Concrete – tension members, simple span and continuous span flexural members, columns and torsion resisting members. Slender reinforced columns.

M. W. Huggins

118. BEHAVIOUR AND DESIGN OF STEEL STRUCTURES

IV – 1 (elective) – – 3 2

The behaviour of structural elements and structures is discussed and related to design methods and criteria. Topics include, repeated loading, brittle fracture, welding, connections, buckling, inelastic behaviour, analysis and design of metal structures by ultimate load procedures. Textbooks: *Structural Steel Design* – Beedle *et al. Canadian Institute of Steel Construction* – Steel Construction Series, Books 1, 2, 3.

119. INDETERMINATE STRUCTURES

IV – 1 (elective) 3 2 – –

A further study of indeterminate structures beyond those of course No. 112. Deflections as well as internal forces, due to various loading conditions, are determined. In most cases non-prismatic members are accommodated. Critical buckling loads for various elastic column situations are computed. Arches, frames and space trusses are examined. An elementary form of analysis by matrix organization is studied as is elementary plate theory.

R. A. Collins

120. CONSTRUCTION ENGINEERING

III – 1 (elective) IV – 1 (elective) – – 3 2

Business and management aspects of construction. Contracts, planning, estimating, scheduling, resource levelling, bidding, cost control and labour relations.

Methods and equipment selection and application in heavy construction. Excavation, tunneling, conveyors, scaffolding, falsework, bracing, formwork, underpinning and underground foundations.

C. Hershfield and Staff in Civil Engineering

132. PUBLIC SPEAKING

IV – 1 — — — 2

A subject emphasizing student participation and designed to develop facility in speaking before a group. Starting with short impromptu talks, the students in small groups move on to longer prepared talks, debating, conducting meetings, introducing and thanking speakers.

H. R. Rice and Staff in Civil Engineering

133. ADMINISTRATION AND MANAGEMENT

IV – 1 2 — — —

Deals with the financing, control, marketing and human relations involved in the operation of a business. The case study method is used and the material in introduced when relevant to the solution of a case.

K. A. Selby, H. L. Macklin

135. ENGINEERING GRAPHICS

I – 1, 3, 4, 5, 6, 7, 8, 9 1 3 1 3

An introductory course designed to give the student a foundation in spatial visualization and an appreciation of the various graphical techniques used in representation and in the solution of engineering problems. The lectures are mainly concerned with descriptive geometry, i.e., with the principles of orthographic, oblique and perspective projection and their use in solving problems involving points, lines and surfaces. In the laboratory, problems are solved in descriptive geometry, engineering drawing, empirical equations, charts and graphs. Both instrument and freehand techniques are used. Textbooks: *Graphic Science* – French and Vierck, 2nd edition; *Graphic Science Problems* – Vierck and Hang, 2nd edition.

C. A. Wrenshall and Staff in Civil Engineering

137. THE ENGINEER AND HIS ENVIRONMENT

II – 1 1 3 1 3

An introduction to the role of the civil engineer in the solution of society's problems. Lectures, seminars and discussion periods by staff of all areas of Civil Engineering and guest speakers. Projects on qualitative solutions to comprehensive engineering problems.

Students work in groups of about 8, and consult staff in Civil Engineering as well as outside agencies.

G. W. Heinke and Staff in Civil Engineering

138. ENGINEERING PRESENTATION

II – 1 1 3 – –

Principles, methods and practice in engineering report writing including methods and procedures of presentation, organization, synopses, nomographs, overlays, drawings and photographs. Practice in presentation in those data, sketches and mechanic drawings necessary for a draughtsman to produce formal engineering drawings.

H. R. Ric

141. PROBABILITY AND STATISTICS

III – 1 2 – –

Topics to be considered include definition of probability, binomial, poisson and norm distributions, frequency and sampling distributions. Examples of estimation, hyp thesis testing and an introduction to the analysis of variance will be covered.

142. ENGINEERING MATHEMATICS

III – 1 3 2 –

Higher order linear differential equations with constant coefficients, introduction t partial differential equations, numerical integration, solution of initial value problem by numerical methods, introduction of finite differences, solution of linear equation an introduction to the analogue computer.

G. T. Wi

145. COMPUTER PROGRAMMING

II – 1 2 2 –

This subject is intended to develop reasonable proficiency in computer programmin techniques and to introduce the more elementary numerical analysis procedures. Th use of flow charts is emphasized and the Fortran IV language is studied extensivel from a user's point of view. In addition, problem-oriented languages such as COG and STRUDL are introduced.

R. A. Collin

153. SURVEYING

II – 1 2 1½ 1 1½

General principles and practice of surveying including: measurement of horizonta distances, horizontal angles, vertical distances. Survey calculations, sources of error corrections and adjustments. Route surveying, construction surveying and introduc tion to air-photo interpretation and photogrammetry.

B. J. Hayne

155. SURVEYING

II – 9 1 – 1

Introduction to surveying principles and practice. Theory and use of surveying instru ments. Survey computations and error analysis, including quantity calculations. Min surveys, topographic surveys, and introduction to practical astronomy. Textbooks *Surveying Practice* – Kissam; *Surveying for Civil Engineers* – Kissam.

B. J. Hayne

156. SURVEYING LABORATORY

II – 9 – 1½ – 1½

First term – field problems using the transit, level and tape. Second term – survey computations related to Course 155.

B. J. Haynes

158. SURVEY CAMP

Course 1, III Year; Aug. 24 to Sept. 11 – Dorset or Gull Lake; Course 9, III Year; August 31 to Sept. 11 – Gull Lake.

Course 1:

(*a*) Adjustments of level and transit, (*b*) Route Surveys, (*c*) Higher Surveys, (*d*) Topographic Surveys, (*e*) Practical Astronomy, (*f*) Photo Interpretation.

Course 9:

(*a*) Topographic Surveying and Mapping, (*b*) Underground Surveying, including Shaft Plumbing and Use of Mine Surveying Instruments, (*c*) Route Surveys, Curve Layout, and Earthwork Quantity Computations, (*d*) Astronomic Observations for Time and Azimuth.

Students in Courses 1 and 9 will be required to take the Survey Camp between the Second and Third Years. Application to defer attendance at the Camp must be made to the Secretary of the Faculty before July 15.

Staff in Civil Engineering

167. ENGINEERING APPLICATIONS OF SURVEYING

III – 1 (elective), IV – 1 (elective) – – 3 2

Theory, methods and instrumentation of engineering surveys. Special applications in Civil Engineering structures such as: bridges, dams, tunnels, highways, airports, powerlines and pipelines, as well as deformation of structures and crustal movement studies. Introduction to hydrographic surveying. Optical tooling and industrial applications.

168. GEODETIC CONTROL SURVEYS

IV – 1 (elective) – – 3 2

The object of Geodetic Control Surveys is to provide a basis for the design and analysis of urban and regional surveys. The following topics are studied: the establishment of vertical horizontal datums and their relation to municipal and national mapping, the reduction of field measurements to a datum surface, a study of electromagnetic survey systems and propagation problems, some elements of physical and geometric geodesy, the relation between astronomic and geodetic coordinates an their determinations, the adjustment and statistical analysis of survey measurement with the application of the electronic computer.

R. C. Gun

170. PHOTOGRAMMETRY AND REMOTE SENSING

IV – 1 (elective) 3 2 –

Ordinary camera as a measuring instrument. Cameras for precise work. Materials an execution of ground and aerial photography. Simple geometry of the photograph. Binocular vision and stereoscopic observation. Simple measurements from stereo pairs o photographs. Methods and means of reconstruction of an exact 3-dimensional mode of the photographed object. Applications in various fields such as surveying, mapping engineering, forestry, architecture, geography, etc. Characteristics of electromagneti spectrum and the basis for remote reconnaisance. Elementary discussion of laws governing absorption, reflection, emission and scattering of radiant energy. Spectral characteristics of natural objects and means of their detection. Examples of remote sensing in natural resource studies. Discussion of earth resource satellites, their orbits, equipment data recovery. Examples of returns as they become available.

180. ENVIRONMENTAL ENGINEERING

II – 1 – – 2 –

This subject introduces problems related to the source and fate of air, water and soi pollutants and their effect on society. The control of pollution by prevention and disposal is discussed.

A. P. Bernhart, P. H. Jones

182. MUNICIPAL ENGINEERING

III – 1 – – 2 2

Quantities of water and waste water, hydrology, waste water collection systems, water distribution systems, municipal roads, refuse disposal, administration and financing of municipal works. Laboratory: Design Problems supplementing lecture material. Textbook: *Water and Waste Water Engineering* – Fair, Geyer and Okun, Volume I.

G. W. Heinke, G. K. Rodgers

183. POLLUTION CONTROL ENGINEERING

IV – 1 (elective) 3 2 – –

Air pollution control, water supply and purification, municipal waste water treatment, industrial waste water treatment, soil pollution control.

A. P. Bernhart, K. Reichert

185. TRANSPORTATION SYSTEMS

III – 1 3 2 – –

Function of transportation, national and urban transportation policy issues, characteristics of transportation systems, principles of location, geometric design of highways and railways, planning procedures.

G. N. Steuart

187. TRAFFIC ENGINEERING

IV – 1 (elective) 3 2 – –

Urban transportation planning, traffic studies, forecasting models, characteristics of traffic flow, traffic control at intersections, methods of project evaluation. Textbook: *Traffic Engineering Handbook.* References: *Principles and Techniques for Predicting Future Demand for Urban Area Transportation* – Martin, Memmott, and Bone; *Highway Capacity Manual.*

R. G. Rice

188. TRANSPORTATION ENGINEERING

IV – 1 (elective) – – 3 2

Characteristics of Transportation Systems, Railway and Airport Engineering, Theory of Traffic Flow, Behaviour and Design of Flexible and Rigid Pavements. Reference books: *Introduction to Transportation Engineering* – Hay; *Planning & Design of Airports* – Horonjeff; *Soil Mechanics for Road Engineers* – D.S.I.R.; *Principles of Pavement Design* – Yoder; *Poisson & Traffic* – Eno Foundation.

189. AIR PHOTO INTERPRETATION

III – 9, IV – 1 (elective 3 2 – –

The principles of interpretation of aerial photographs; processes of formation, drainage, and erosion of landforms, both unconsolidated and consolidated with particular emphasis on glaciation; terrain patterns as seen on aerial photographs, their identification and evaluation, and the engineering problems involved; location of granular materials, soil mapping; location of surface and groundwater supplies; investigations from airphotos for highway, powerline, and pipeline locations, damsites, flood control structures and shoreline structures; classification of organic terrain and prediction of depth; arctic and subarctic terrain interpretation and problems; existing land use classification; land capability for various uses; site selection and planning; summary and potential engineering applications of colour, infrared colour, infrared and radar imagery. The course will concentrate on the recognition of general and particular engineering problems or benefits, and total environmental conditions from existing aerial black and white photographs. There will be a one-day field trip in early November to verify specific interpreted information.

S. J. G. Bird

191. SOIL MECHANICS AND FOUNDATIONS

III – 1, IV – 9 2 1½ 2 1

Identification and classification of soils for engineering purposes, weight-volume relationships, compaction, permeability and drainage characteristics, effective stresses, settlement, shearing strength, site exploration and soil sampling. Bearing capacity, footings, consolidation and settlement, lateral pressure, retaining walls, braced cuts an cofferdams, pile and caisson foundations, sheet pile bulkheads, slope stability, flo nets, dewatering. In addition to lectures there will be laboratory testing and proble periods.

E. Robinsk

193. FOUNDATIONS AND EARTHWORKS

IV – 1 (elective) – – 3

Design and construction of: Foundations for buildings, bridges and other structure including excavation, footings, piling, caissons; Retaining walls, sheet pile bulkheads tunnels; Fills, embankments, earth-fill and rock-fill dams including seepage, dewaterin and grouting. Geotechnical processes and field measurements and control.

E. Robinsk

194s. ENGINEERING GEOLOGY

IV – 1 (elective) – – 3

The study of engineering practice from a geological point of view. The behaviour o rocks and soils in building and engineering construction, foundations, tunnels, dams and flood-control works with reference to the importance of the mineral compositio of earth and rock materials, their geomorphic and geologic features and their stres history. Engineering case studies will include examination of groundwater, frost an landslide conditions, shoreline engineering, construction in permafrost, earthquak problems, and field investigations.

A. K. F. Turne

195. MINING

II – 9 1 – 1 2

A combined lecture and laboratory subject in the principles of mining and its unit processes. Emphasis is placed on the statistical approach to sampling calculations.

H. R. Rice

196. MINING TECHNOLOGY AND MINERAL DRESSING

III – 9 2 – 2 –

An introduction to mining practice with emphasis on current mining methods as applied to geological situations and stress environments; current practices in mineral beneficiation processes.

H. R. Rice

197. MINE OPERATION AND ADMINISTRATION

IV – 9 2 – 2 –

Mine operation with special attention paid to mine services; administration dealing with aspects of economics, industrial engineering, finance, and industrial relations.

H. R. Rice

198. MINING LABORATORY

IV – 9 – 3 – 3

Problems in mine layout involving shaft location and size; mine development; choice of stoping methods, mining rate, and mine equipment; time and cost schedules; ore reserve calculations.

DEPARTMENT OF MECHANICAL ENGINEERING

303. STATISTICAL THERMODYNAMICS

III 5nt – – 2 –

A development of thermodynamics in which the ensemble approach is used to treat isolated, closed and open systems; to include such topics as the Liouville theorem, statistical equilibrium, partition functions, specific heats, and fluctuations in thermodynamic properties.

308. HEAT ENGINEERING

III – 3 – – 3 2

Applications of thermodynamics to machines, including: background to the development of heat engines; basic steam power plant cycles and design; internal combustion engines and cycles; combustion calculations; fuel and exhaust products analysis; power plant testing; heat transmission; psychrometry and air conditioning.

A. B. Allan

309. ENGINEERING THERMODYNAMICS

III – 3 2 – 2 –

Fundamentals of the effects of heat on fluids, including: first and second laws of thermodynamics; ideal processes using gases and vapours; reversibility, availability and entropy; properties of real and ideal fluids; processes and cycles for gas and vapour power plants; processes and cycles for refrigeration.

F. C. Hooper

310. HEAT ENGINEERING LABORATORY I

III – 3 – 3 –

Complementary to lecture subjects 308 and 309. The experimental work, conducte on a broad range of heat and power equipment, is intended to offer experience in th design, organization and execution of experimental investigations of thermal apparatu in the application and evaluation of the associated instrumentation, in the treatment c the data, and in the interpretation and reporting of the work. Textbook: *The Eng neering Report in the Undergraduate Laboratory* – Hughes.

313. HEAT ENGINEERING

III – 5nt 1 3 1

This course consists of a study of the fundamental concepts of macroscopic thermc dynamics, and their applications to closed and open dynamic systems. An examinatio of the principal power cycles is undertaken in relation to the properties of the workin media involved. Emphasis is placed on a thorough understanding of the three basi laws of thermodynamics. Textbook: *Concepts of Thermodynamics* – Obert. Referenc books: *Engineering Thermodynamics* – Hall and Ibele. *Thermodynamics* – Van Wyle

C. A. War

319. HEAT TRANSFER

IV – 3 2 1½ 2 1

Fundamentals of heat transfer with practical application, steady state conduction natural and forced convection for laminar and turbulent flows, radiation heat transfer transient systems, combined heat transfer processes, introduction to mass transfer practical applications, heat exchangers. Textbook: *Principles of Heat Transfer* *F. Kreith.*

A. H. Abdelmessil

322. MICROSCOPIC THERMODYNAMICS

IV – (elective) 2 – 2 1

Elementary kinetic theory concepts such as collision frequency, distribution function transport phenomenon, thermodynamic properties, phase space and the Boltzmann equation; classical statistical mechanics concepts of ensembles, partition functions anc their use; introduction to quantum mechanics; the quantum statistical mechanics o Bose-Einstein and Fermi-Dirac systems, translational, rotational, vibrational, electronic, nuclear partition functions; other related topics. Textbook: *Microscopic Thermodynamics* – Pierce.

C. A. Wara

323. THERMAL POWER GENERATION

IV – 3 (elective) 2 – 2 1½

Plants and processes in major production, overall design and heat balance in steam plants, non-central power production, characteristics of portable power units, fossil fuels and nuclear energy, combustion theory and introduction to combustion problems, principles and potential of new devices currently under development, magnetohydrodynamics power, fuel cells, thermionic and thermoelectric power.

P. B. Hughes

328. HEAT TRANSFER

IV – 5nt – – 2 –

Steady state and transient conduction, surface and gas radiation, convection, boiling, condensation and combined mechanisms are considered. Special attention is given to analogue and computational procedures and to consideration of the manner in which novel or complex problems may be approached. Textbook: *Heat Transmission* – McAdams.

F. C. Hooper

331. THERMAL ENERGY CONVERSION

IV – 5nt 3 3 3 3

The thermodynamics and gas dynamics of thermal energy conversion. Steam power cycles, nuclear reactor and fossil fuel energy sources, magnetohydrodynamics power generation, fuel cells, combustion, refrigeration, new trends and research developments.

D. S. Scott

333. FLUID MECHANICS AND HYDRAULICS

III – 1 2 – 2 3

Properties of fluids, fluid statics, pipe-line flows, compressible flows, momentum and energy equations, dimensional analysis, free surface flows, flow around submerged bodies, turbulent flows, pumps, water hammer and surge tanks.

D. F. James

334. FLUID MECHANICS I

III – 3 2 – 2 3

Introductory concepts; fluid properties, dimensional analysis; hydrostatics; kinematics and dynamics of flow; irrotational flow and vorticity; dynamic lift; laminar flow; turbulent flow; applications to closed-conduit and open-channel flow; one-dimensional compressible flow.

G. R. Lord

337. FLUID MECHANICS AND THERMODYNAMICS

III – 4 – – 2 3

Fluid properties and equation of state, momentum and energy equations; dynamics of flow, laminar and turbulent flow, closed-conduit flow.

Laws of thermodynamics, the Carnot cycle, real and ideal fluids, power cycles, psychrometry and heat transfer.

D. F. James, F. C. Hooper

338. FLUID MECHANICS

III – 5C 2 3 – –

Presentation of fundamentals of continuum fluid motion; introductory concepts; kinematics and dynamics of flow; irrotational motion; viscous laminar and turbulent flow; thermodynamic relationships; gravity effects; applications.

J. F. Keffer

339. FLUID MECHANICS

III – 6 2 3 – –

Introductory concepts; fluid properties; fluid statics; kinematics and dynamics of flow; laminar and turbulent flow; closed-conduit and open-channel flow; compressibility effects; drag and lift on submerged bodies; elementary turbomachinery.

J. F. Keffer

340. FLUID MECHANICS

III – 5nt 2 3 2 3

A fundamental approach to the mechanics of fluid motion; continuum concepts; kinematics and dynamics of flow; irrotational motion; vorticity; laminar flow solutions; turbulent motions; applications to conduit flow; thermodynamic relationships; elementary thermal transport; free surface waves; fluid machinery.

J. F. Keffer

341. FLUID FLOW AND HEAT TRANSFER

III – 8 2 – 2 3

A study of the forces and motion produced by various fluid properties. Gravitational, viscous and inertial forces are considered in detail. Momentum, energy and continuity relation, boundary-layer approximation, turbulence, flow in pipes and around submerged bodies. Steady-state conduction in one dimension; extended surfaces; heat conduction with two or more independent variables; forced convection and dimensional analysis; heat transfer by free convection; radiant heat transfer; heat transfer by combined conduction and convection; heat transfer in liquid metals.

A. H. Abdelmessih, H. J. Leutheusser

343s. HYDRAULIC ENGINEERING

IV – 1 (elective) – – 3 2

Review of the flow principles in a fluid. Field measurements of groundwater flows and flows into wells. Open channel and closed conduit flow. Hydraulic structures and appurtenances, transitions controls; dams; navigation works, methods of construction. Hydraulic machinery, pumps, turbines, power and control systems. Design and testing of hydraulic engineering systems; analytical procedures, numerical methods and computer simulation. Systems analysis.

L. E. Jones

344. APPLIED FLUID MECHANICS

IV – 3 2 1½ 2 1½

Pipe, networks; one dimensional gas dynamics including simple area change, simple friction, simple heating, generalized flow and normal shock waves; hydraulic transients including surges and water hammer; flow machines; fluid power circuits; other topics of engineering significance.

Problems and experiments in applied fluid mechanics.

H. J. Leutheusser

345s. WATER RESOURCES AND HYDROLOGY

IV – 1 (elective) 3 2 – –

Management of water as a resource for optimal use. Qualitative and quantitative evaluation of surface and ground water sources. Natural and artificial recharge mechanisms. Multiple purpose impoundments for drainage, flood control, irrigation and water supply. Natural and man-made upsets in ecological systems resulting in impairment of natural water sources. Rainfall, runoff, streamflow, measurements, predictions and mathematical models.

Staff in Civil and Mechanical Engineering

346. FLUID MECHANICS II

IV – 3 (elective) 2 – 2 1½

Flow of an ideal fluid, complex variable analysis, lift, finite wing theory, viscous fluid flow, simple solutions of Navier-Stokes equations, lubrication theory, boundary-layer theory, drag of streamline bodies, turbulent flow, diffusion in turbulence, dynamics of submerged bodies, introduction to aeroelasticity, free surface phenomena.

J. F. Keffer

351. DYNAMICS

II – 3 3 1½ – –

Calculus of vectors; particle motion; systems of particles; rigid bodies; virtual work and D'Alembert's principle; introduction to Lagrange equations; introduction to mechanical vibrations.

R. C. Flanagan

352. DYNAMICS

II – 7 3 2 – –

Dimensional units; vectors; kinematics, rectilinear and angular motion, plane motion, projectiles; satellite orbits, rigid body concept, relative motion with respect to translating and to rotating vehicles; kinetics, force, d'Alembert's principle, rotation, translation, vibration of mechanical and electrical systems, work, energy, conservation of energy, power, impulse, momentum, rockets, jets, fluid mechanics, impact, balancing, centrifugal and Coriolis' force, critical speeds, gyroscopic effect. Reference book: *Vector Mechanics for Engineers – Dynamics* – Beer and Johnston.

D. McCammond

356. DESIGN OF MACHINE ELEMENTS

II – 3 – – 2 3

Course 3, II Year; 2 hrs. lectures per week, second term. Standard methods for the design of belts, shafts, spur gears, bearings, brakes, clutches, couplings, power screws, fasteners, rivets and welded components. Textbook: *Mechanical Engineering Design* – Shigley.

D. McCammond

358. THEORY OF MACHINES

II – 3 – – 2 3

Equations for accelerated motion of mass applied to the analysis of machine elements. Velocity, acceleration, force distribution, speed fluctuation and balancing of machine parts and machines. Cams, gears, flywheels and linkage kinematics. Textbook: *Kinematics and Dynamics of Machinery* – Maxwell.

G. E. Godfrey

360. SYSTEMS DYNAMICS

III – 3 1 – 1 –

Setting up of the differential equations of physical systems; frequency response and bandwith concepts; the analogue computer; transducers and instrumentation; frequency response and transient response, consideration in the matching of processes.

D. L. Allen

361. VIBRATIONS

III – 3 2 – – –

Single-degree-of-freedom systems, damped and undamped; multi-degree-of-freedom systems; method of determining natural frequencies; characterization of physical systems by mathematical models; response of such systems to steady-state single-frequency excitation and to transient pulses; beams and strings.

B. Tabarrok

362. DYNAMIC MEASUREMENTS LABORATORY

III – 3 – 3 – 3

A combined laboratory course for Vibrations (361) and Systems Dynamics (360). Includes: comparative experiments with transducers; analogue computer study of transient and frequency response behaviour of physical systems; vibration experiments; experimental study of electrical-mechanical-fluid-thermal analogies; measurements of the process dynamics of a variety of systems, including consideration of the optimum choice of transducers and instrumentation and the comparison of transient and frequency response.

363. ENGINEERING DESIGN

III – 3 – – 2 –

Approach to engineering design; problem definition; generating and comparing concepts; synthesis-analysis-evaluation decisions under realistic situations. Engineering examples and small design projects utilizing available background of mathematics, mechanics, circuits and thermodynamics. Specific attention is given to such subjects as springs, curved beams and experimental stress analysis.

I. W. Smith

364. ENGINEERING DESIGN LABORATORY

III – 3 – – – 3

A laboratory course complementary to the lectures of subject 363, Engineering Design.

365. EXPERIMENTAL STRESS ANALYSIS

III – 5nt, 5p 2 – 1 3

The elementary concepts of the theory of elasticity will be given. The experimental techniques of measuring stress or strain will be studied; these techniques include strain-gauge, photoelastic, brittle-coating and moire methods.

G. E. Godfrey

367. APPLIED MECHANICS

IV – 3 2 1½ 2 1½

Beams on elastic foundations, energy methods, torsion of non-circular cylinders and open sections, thick discs, composite cylinders, equations of two-dimensional elasticity, description of continuous media. Review of particle dynamics, Lagrange's equations, Hamilton's principle, gyroscopic dynamics, non-linear vibrations, phase plane, vibrations of continuous elastic media, rocket dynamics, outer space dynamics.

R. C. Flanagan, B. Tabarrok

374. MANUFACTURING SCIENCE

IV – 3 (elective) 2 – – –

Review of traditional production processes including casting, forging, cutting, etc.; science of metal removal; economics of production; sintering, EDM, ECM, explosive forming, etc.; numerical control and automation. Textbooks: *Processes and Materials of Manufacture* – Lindberg; *Manufacturing Analysis* – Cook.

R. G. Fenton

375. DESIGN METHODOLOGY

IV – 3 (elective) – – 2 1½

Morphology of design decision making; computer-aided graphic and design methods, optimization, reliability, value engineering.

R. G. Fenton

380. DIFFERENTIAL EQUATIONS

II – 3 – – 2 –

Engineering applications of elementary differential equations, to include such topics as operational methods, elementary nonlinear equations, simultaneous differential equations.

Staff in Mechanical Engineering

386. ENGINEERING MATHEMATICS I

III – 3 3 1 – –

Analytical techniques used in mechanical engineering, including such topics as ordinary differential equations, Laplace transform, numerical solution of ordinary differential equations, series, series solution of differential equations, Bessel functions, Legendre functions, Boundary and initial value problems.

W. D. Baines

387. ENGINEERING MATHEMATICS II

III – 3 – – 3 1

Continuation of subject 386 including Fourier series, Fourier-Bessel series, Legendre series, Vector analysis, line and surface integrals, transformation of co-ordinate systems, solution of partial differential equations by separation of variables, simple problems in heat conduction, vibration of strings and membrances, analytic functions of a complex variable.

W. D. Baines

390. ENGINEERING MATHEMATICS II

IV – 3 (elective) 2 – 2 1½

Partial differential equations in engineering including such topics as Fourier series and integrals, integral transforms, classification of partial differential equations, solutions of the Laplace, diffusion and wave equations.

I. G. Currie

391. CONTROL SYSTEMS

IV – 3 2– 2 –

Analysis and synthesis of linear feedback control systems, by frequency response methods and the s-plane approach; application to some common systems for the control of industrial machinery and processes; introduction to non-linear, to sampled-data and to digital control systems.

J. VandeVegte

392. CONTROL SYSTEMS LABORATORY

IV – 3 – 1½ – 1½

Problems and experiments designed to accompany lecture course 391.

394. CONTROL ENGINEERING

III – 4 – – 2 2

An introduction to the dynamic behaviour of linear systems; the feedback principle; stability of linear control systems; the convolution theorem; transfer functions of linear systems; analysis of linear control systems; introduction to servo-mechanism technology. Problems and laboratory experiments will accompany the lectures.

J. S. Ansari

398. CONTROL SYSTEMS

IV – 5a, 5g, 5nt 2 – 1 –

Linear control systems by the transfer function technique and the state space approach. Elementary nonlinear control systems. Introduction to sampled-data and to digital control systems. Introduction to optimal control.

J. VandeVegte

399. CONTROL SYSTEMS LABORATORY

IV – 5a, 5g, 5nt — — — 3

A laboratory course accompanying subject 398.

DEPARTMENT OF INDUSTRIAL ENGINEERING

414. ELEMENTS OF INDUSTRIAL ENGINEERING

II – 4 2 – 2 –

A broad survey of both old and new elements of Industrial Engineering, with selected reading and essay assignments, including work study, wage determination, controls of production, quality and cost, mathematical models of production and distribution systems, computer simulation techniques, operational research, human factors studies, and management science.

B. Bernholtz, J. Vanderheyden

415. CONTROL OF PROCESSES

IV – 4 2 1½ 2 1½

Short Survey of Systems Engineering. Goals and Decisions: Philosophical Issues of Value Judgements. Physical and Economic Models: System Analysis. Linear and Geometric Programming. State Space Representation of Linear and Nonlinear Systems. Solution of State Space Equations. Stability, Controllability and Observability. Sampled-Data Systems. Steady-State Process Optimization: Well-Defined Processes, Adaptive Control, Evolutionary Optimization. Dynamic Process Optimization: Calculus of Variations, The Maximum Principle, Dynamic Programming. Computer Process Control. Business, Engineering and Economic Applications.

J. M. Tusiewicz

418. MANAGEMENT SCIENCE

IV – 4 2 1½ 2 1½

The course presents the basic principles of decision making. It includes such concepts as the expression of individual choice by indifference curves, the analysis of data by Bayesian inference, the value of accurate information, and the use of cardinal utility to represent aversion to risk. The concepts are illustrated with industrial applications.

T. A. Lambe

421. THESIS PROJECT

IV – 4 – 3 – 3

Design and analysis of an engineering system to satisfy certain objectives and requirements (e.g. the production of a specific product). This project will provide the student with an opportunity to apply the knowledge and techniques of analysis acquired in all the other Industrial Engineering subjects. The work will be carried out under the supervision of staff members. Progress reports and a written thesis are required.

Staff in Industrial Engineering

422. COMPUTERS AND PROGRAMMING I

II – 4 22 – –

Coding and programming for the digital computer; machine organization, machine language and symbolic compiler language (FORTRAN IV); number representation and conversion. Laboratory exercises are drawn from the fields of engineering and applied science, as well as from those of data processing and elementary compilation.

R. W. P. Anderson

423. COMPUTERS AND PROGRAMMING II

III – 4 22 – –

An extension of the Second Year subject Computers and Programming I. More advanced discussion of general and specialized compiler languages and their application in business, engineering and other fields; simulation, data processing, and list processor languages; Monte Carlo methods; GPSS, SIMSCRIPT, COBOL, etc. Laboratory problems are selected to complement the lecture material.

R. W. P. Anderson, S. H. Cohn

424. OPERATIONAL RESEARCH I

III – 4 2 2 2 2

The course provides an introduction to the methodology, techniques and applications of Operational Research. The processes of model building and solution are illustrated, throughout the course, using simplified case studies. These studies will include examples of decision problems of inventory, replacement and reliability, allocation, queueing, competition, sequencing and co-ordination. The course will also include introductions to the mathematical techniques of linear and integer programming, dynamic programming, branch and bound methods, simulation, CPM – PERT, and Markov processes.

A. A. Cunningham

425. MAN AS AN INFORMATION PROCESSOR

IV – 4 – – 2 –

The design of equipment and systems of equipment for effective use by human beings.

P. J. Foley

426. DIFFERENTIAL PSYCHOLOGY

IV – 4 2 – – –

The study of individual differences in intelligence, achievement, aptitude and personality, as well as differences related to sex, age, racial and cultural factors. Problems and methods of psychological measurement.

J. L. Vitalis

427. MAN AS A MACHINE

IV – 4 2 – – –

Detailed study of the biological bases and correlates of behaviour with emphasis on the analysis of sensory systems.

P. J. Foley

428. ORGANIZATIONAL PSYCHOLOGY

IV – 4 – – 2 –

Individual and group behaviour in work organizations. Relevance to human behaviour and management problems, supervision, communications, motivation and the implementation of change.

E. L. Vitalis

429. SYSTEM SIMULATION

IV – 4 2 1½ – –

Computer simulation models. The theory will be developed and applied to problems in the design and analysis of queueing, inventory, maintenance, reliability, transportation, and resource allocation systems.

I. B. Turksen

430. INFORMATION AND OPTIMIZATION

IV – 4 – – 2 1½

Introduction to information theory; topics in optimization theory.

J. G. C. Templeton

DEPARTMENT OF CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

600. CHEMISTRY

I – 1, 3, 4, 6, 7, 8, 9 2 – 2 –

Chemical theory, with industrial and engineering applications.

The Staff in Chemical Engineering

601. CHEMICAL LABORATORY

I – 1, 3, 4, 5, 6, 7, 8, 9 – 3 – 3

A laboratory course illustrating the fundamental laws of chemistry as dealt with in the lecture course, and providing an introduction to chemical analytical methods.

W. F. Graydon, M. J. Phillips, S. Sandler, A. M. Rozeiu

602. CHEMISTRY

I – 5 2 – 2 –

Introductory physical chemistry: the gas laws, chemical equilibria, elementary solution chemistry, thermochemistry. Problems dealing with industrial and engineering applications.

W. H. Burgess

608. PHYSICAL CHEMISTRY

II – 5 2 – 2 –

The themes discussed are conservation, equilibrium and rate of change in chemical systems. These are applied to topics in thermo-chemistry, phase equilibrium, reaction equilibrium, including reactions in cells, and reaction kinetics. Reference books:

Physical Chemistry, by F. Daniels and R. A. Alberty, 3rd ed.; *Physical Chemistry*, by W. J. Moore, 3rd ed.

C. E. Chaffey

609. PHYSICAL CHEMISTRY LABORATORY

II – 5 – 1½ – 1½

Experimental work and problems periods to accompany subject 608. In the second term, each student performs a laboratory investigation of an individual problem of a research type. Alternate periods are devoted to solving assigned problems.

C. E. Chaffey

613. ANALYTICAL CHEMISTRY

II – 6

This course commences on Tuesday, September 1, and continues until the opening of the Fall Term. All the working time will be spent on systematic qualitative inorganic analysis. Textbook: *Quantitative Chemical Analysis* – Fischer and Peters.

J. W. Smith, W. A. M. Hewer, J. Binkiewicz, M. J. Phillips

614. ANALYTICAL CHEMISTRY LABORATORY

II – 6 – 9 – –

A continuation of subject 613.

J. W. Smith, W. A. M. Hewer, J. Binkiewicz, M. J. Phillips

615. ANALYTICAL CHEMISTRY

II – 6 2 – – –

Equilibrium considerations in quantitative analysis. Textbook: *Solubility and pH Calculations* – Butler.

J. W. Smith

617. INORGANIC CHEMISTRY

II – 6, 8, 9 1 – 2 –

Review of periodic classification. Modern atomic structure, elements of nuclear theory. Fundamental properties of elements. Chemical bonding in molecules. Solid state theory and solid structures. Descriptive chemistry of selected elements.

R. E. Jervis

619. CHEMICAL ENGINEERING SCIENCE LABORATORY

II – 6 – – – 7½

Experiments illustrating the kinetic and equilibrium principles of chemical engineering. Mass and heat balance calculations. One laboratory report per week.

I. H. Spinner, W. A. M. Hewer, C. P. Brockett, M. J. Phillips

620. PROCESS CALCULATIONS

II – 6 – 3 – 3

Process calculations in chemical engineering. Textbook: *Basic Principles and Calcu-*

lations in Chemical Engineering – Himmelblau.

J. W. Smith, I. H. Spinner

622. PHYSICAL CHEMISTRY

II – 6 **2 – 2 –**

The themes discussed are conservation, equilibrium and dynamics in chemical systems. These are applied to topics in thermochemistry, phase equilibrium, reaction equilibrium, including reactions in cells, surface phenomena and reaction kinetics. Reference books: *Physical Chemistry* – F. Daniels and R. A. Alberty, 3rd ed.; *Physical Chemistry* – W. J. Moore, 3rd ed.

R. W. Missen

625. REACTION KINETICS

III – 6 **1 – 1 –**

Chemical kinetics; principles of adsorption and colloid chemistry.

W. H. Burgess

626. SYNTHETIC CHEMISTRY

III – 5c **1 – 1 –**

A course in synthetic chemistry covering the principles of systematic organic chemistry and systematic inorganic chemistry.

R. Woodhams

627. CHEMICAL LABORATORY

III – 6 **– 6 – 6**

A laboratory course to accompany subject 640. One laboratory report.

W. F. Graydon, Z. May

628. ORGANIC CHEMISTRY

III – 6 **2 – 2 –**

An introductory course in organic chemistry, with emphasis on structure.

J. G. Breckenridge

629. ORGANIC CHEMISTRY LABORATORY

III – 6 **– 6 – 9**

A laboratory course accompanying subject 628.

W. H. Rapson, Z. May

630. INDUSTRIAL CHEMISTRY

III – 6 **2 – 1 –**

Selected topics in the chemical process industries. The course illustrates how the principles of chemistry, engineering and economics are applied in industry. Textbook: *Chemical Process Industries* – R. N. Shreve.

Staff in Chemical Engineering

631. INTRODUCTION TO MASS AND HEAT TRANSFER

II – 6 **2 – 2 –**

The fundamental theory and practice used in transfer operations in chemical engineering. Energy and mass transfer are considered in the study of the flow of fluids, fluidization of solids, heat transfer, and evaporation of solutions. Textbook: *Principles of Unit Operations* – Foust *et al.*

W. G. MacElhinney

632. FLUID MECHANICS

III – 6 **– – 2 –**

Applications of the fundamentals of fluid mechanics in chemical engineering, with emphasis on single- and two-phase flow with and without heat transfer, fluid-particle dynamics and non-Newtonian fluid flow.

M. E. Charles

633. APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

III – 6 **1 1 1 1**

The first term is devoted to analysis and solution of chemical engineering problems which require knowledge of the rational design of experiments, treatment of experimental data and tests of hypotheses. The second term is devoted to applications of differential equations to problems of chemical engineering interest; emphasis is on the formulation of differential equations, together with their solution by analytical and numerical methods. Reference Books: *Probability and Statistics for Engineers* – I. Miller and J. E. Freund. *Engineering Statistics* – A. H. Bowker and G. J. Lieberman. *Applied Differential Equations* – M. R. Spiegel.

I. H. Spinner, R. Luus

634. CHEMICAL BONDING, PROPERTIES AND REACTIVITY

III – 5m **2 – 2 –**

The compounds of the principal elements and their physical and chemical properties are discussed. Tools ranging from classical concepts and equations to Quantum Mechanics are used to understand, predict and classify this information.

R. E. Jervis

640. CHEMICAL ENGINEERING THERMODYNAMICS

III – 5c 2 – 2 –
III – 6 2 2 2 2

A tutorial course in classical thermodynamics with problems in the field of applied chemistry and chemical engineering. Special emphasis is placed on chemical processes and compositional changes.

W. F. Graydon

641. CHEMICAL ENGINEERING RATE PROCESSES

III – 5c **– – 3 –**

Introduction to mass, momentum and energy transport. Kinetic theory of gases, calculation of transport properties; analytical solutions of problems in viscous flow, heat conduction and mass diffusion; turbulent transfer coefficients; applications to chemical engineering systems. Textbook: *Transport Phenomena* – Bird, Stewart and Lightfoot.

O. Trass

642. CHEMICAL ENGINEERING PROBLEMS AND LABORATORY

III – 5c – 9 – 7½

Problems and laboratory experiments illustrating topics discussed in subjects 640, 641, and 626.

Staff in Chemical Engineering

650. MASS TRANSFER OPERATIONS

III – 6 2 1 2 1
IV – 5c 2 – 2 –

The theory and practice of mass transfer operations in chemical engineering are discussed. Many problems in distillation, extraction, absorption, and other operations illustrate the course. Textbook: *Mass Transfer Operations* – 2nd Ed. R. E. Treybal.

D. Mackay, O. Trass

651. CHEMICAL PLANT DESIGN

IV – 6 (elective) 2 3 – –

The lectures take a systems approach to the design of chemical plant, proceeding from the origin through major design considerations to technical and economic feasibility. Considerations applying to overseas situations, and the relationship of design to operation are included. In the plant design laboratory teams of students design and evaluate a particular plant. Textbook: *Plant Design & Economics for Chemical Engineers* – Peters & Timmerhaus. Reference book: *Fundamentals of Cost Engineering in the Chemical Industry* – Bauman.

M. Wayman, D. Mackay

652. CHEMICAL ENGINEERING LABORATORY

IV – 5c, 6 – 9 – –

A laboratory course to accompany subjects 631, 632, 650, and 651. Bench and pilot plant experiments are carried out to study a variety of unit operations such as fluidization, heat transfer, evaporation, filtration, distillation, extraction, and absorption. Modern control instruments are discussed and operated. One laboratory report per week.

R. F. Hunter and Staff in Chemical Engineering

653. PROCESS MODELLING AND SIMULATION

IV – 6 (elective) 2 3 – –

The mathematical modelling of steady and unsteady states in typical processes involving fluid flow, heat and mass transfer, vapour-liquid equilibria, and chemical reaction. Solution by analytical, analogue, and digital methods. Introduction to controller response modes.

D. Basmadjian, M. E. Charles, I. H. Spinner

655. CHEMICAL ENGINEERING THERMODYNAMICS

IV – 6 (elective) 2 – – –

A continuation of Course 640. Special emphasis is placed on the properties of real gases and of solutions of non-electrolytes, and on chemical equilibria.

W. H. Burgess

656. PUBLIC SPEAKING

IV – 6 – – 2 –

Staff in Chemical Engineering

660. SELECTED TOPICS IN ORGANIC CHEMISTRY

IV – 5o 2 – 1 –

A short course in the preparation, structure, and reactions of carbohydrates, proteins, heterocyclic compounds, chemotherapeutic agents, steroid hormones, alkaloids, and synthetic organic polymers.

P. Y-C Wang

661. ORGANIC CHEMISTRY LABORATORY

IV – 5c – – – 6

A laboratory course to accompany subject 660.

Z. May

662. PROCESS CONTROL

IV – 6 (elective) – – 2 –

Fundamentals to optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: *Optimal Control of Engineering Processes* – Lapidus and Luus.

R. Luus

663. INSTRUMENTAL METHODS

IV – 6 (elective) – – 2 –

The subject is designed to emphasize the science of chemical instrumentation. The principles, technique, and applications of gas-chromatographic, opticometric, electrometric, and mass-spectrometric methods of analysis are studied.

S. Sandler

664. PROCESS DYNAMICS

IV – 5o 2 – 2 3

Analysis and control of chemical engineering systems with emphasis on non-linear methods; phase plane; Liapunov's method; averaging technique. Introduction to optimal control of processes; extraction train, distillation column, and chemical reactors.

R. Luus

665. THERMODYNAMICS OF CHEMICAL SYSTEMS

IV – 5o 3 – – –

Development of the principles of chemical equilibrium and of statistical mechanics; application to both non-reacting and reacting systems, with emphasis on behaviour of multicomponent mixtures and complex reactions, and the calculation of thermodynamic properties in the ideal-gas state. Reference books: *The Principles of Chemical Equilibrium*, by K. G. Denbigh; *Molecular Thermodynamics of Fluid Phase Equilibria* – J. M. Prausnitz.

R. W. Missen

666. CHEMICAL ENGINEERING DESIGN

IV – 5c 2 6 2 6

Applications of heat transfer and fluid flow, mathematical modelling, and optimization in chemical engineering and chemical plant design. In the first term the laboratory is devoted to problems in these topics and in those of subject 665. In the second term, simultation and optimization are carried out for a particular chemical plant. Reference books: *Applied Mathematics in Chemical Engineering* – Mickley, Sherwood, and Reed. *Chemical Reactor Theory* – Denbigh. *Chemical Reaction Analysis* – Petersen.

J. W. Smith, M. E. Charles, M. Wayman, D. Mackay

667. DYNAMICS OF CHEMICAL SYSTEMS

IV – 5c – – 3 –

Elements of chemical rate process, complex chemical system dynamics, chemical reactor stability. Application of analogue computers to the solution of problems in above topics.

I. H. Spinner

668. APPLIED NUCLEAR CHEMISTRY

IV – 6 (elective) – – 2 –

An introduction to the principles and methods of radioisotope chemistry. Applications of nuclear techniques and radioactive materials in chemical technology and in nuclear power generating systems. Topics to be covered include: radioisotope methods of studying chemical reaction mechanisms and kinetics; chemical process development and process control; nuclear reactions applied to chemical analysis (activation analysis); production of nuclear materials such as uranium, plutonium, heavy water; chemical processing of irradiated reactor fuels; radiation chemical processing.

R. E. Jervis

669. ADVANCED SEPARATION PROCESSES

IV – 6 (elective) 2 – – –

Theory and application of a number of separation processes, including multicomponent distillation (using computational techniques), azeotropic and extractive distillation, liquid extraction, transient behaviour and cyclic processes, thermal diffusion separations, and solid-liquid contacting operations. Illustrative design problems.

D. Mackay, O. Trass

670. NUCLEAR ENGINEERING

IV – 5nt 2 – 2 –

Nuclear engineering aspects of: nuclear constitution and properties including cross-section, energetics, radioactivity, production and use of radio-isotopes, neutrons, slowing down, "age" theory, diffusion of thermal neutrons, fission. The age and two-group theories of the reactor core. Reflected reactors (elementary treatment). Reactor kinetics, control and instrumentation. Applications of heat transfer, fluid flow and stress analysis to the reactor core. The measurement and control of radiation. Exposure of humans to radiation. Shielding techniques. Nuclear engineering applications of nuclear and radio-chemistry.

D. G. Andrews, R. E. Jervis

671. NUCLEAR ENGINEERING LABORATORY

IV – 5nt — – 3 – 3

A laboratory course to accompany subject 670. Experiments are carried out with radiation sources and instruments, a sub-critical reactor, a reactor simulator, pulse height analyzers, fast neutron generators and radioactive tracers.

D. G. Andrews, R. E. Jervis

672. MOLECULAR THERMODYNAMICS

IV – 6 (elective) — 2 – – –

Molecular thermodynamics is the use of classical and statistical thermodynamics, together with knowledge of molecular behaviour, in equilibrium analysis of chemical systems. After development of principles and working tools, applications are made to fluid behaviour, and phase and reaction equilibrium.

R. W. Missen

673. STRATEGY OF PRODUCT AND PROCESS ENGINEERING

IV – 6 (elective) — 2 3 – –

The strategical approaches needed for the solution of engineering problems involving the creation of novel unit operation equipment and novel processes, both for chemical and non-chemical products.

R. F. Hunter, I. H. Spinner

674. PIPELINE TRANSPORTATION

IV – 6 (elective) — 2 – – –

A course based on the theory and practice of moving gases, liquids and solids by pipeline both within chemical plant and over long distances. Operating pipeline systems are used as examples, and the course includes a feasibility and design study.

M. E. Charles

675. CONVECTIVE HEAT AND MOMENTUM TRANSFER

IV – 6 (elective) — 2 – – –

A continuation of earlier courses on convective heat and momentum transfer in flowing fluids. A phenomenological approach based on current research.

J. W. Smith

676. POLYMER ENGINEERING

IV – 6 (elective) — 2 – – –

A course covering the structures and properties of organic high polymers, and how these affect specific applications requiring plastics, elastomers, fibers, or composites.

H. L. Williams

677. WOOD CHEMISTRY

IV – 6 (elective) 2 – – –

The organic and physical chemistry of cellulose, lignin, hemicelluloses and extractives of wood, and its application to the technology of pulping and bleaching in the manufacture of paper pulps.

W. H. Rapson

678. COMPOSITE MATERIALS

IV – 6 (elective) – – 2 –

A course on the fundamental principles of the science of composite materials. Topics will include the reinforcement of plastics, metals, ceramics and elastomers with fibers, flakes, and other particulate fillers.

M. R. Piggott, R. T. Woodhams

679. CERAMICS

IV – 6 (elective) 2 – – –

An introduction to the field of ceramics, including a description of the available raw materials, the production of refractories and glasses, and high-temperature experimental techniques.

D. Barham

680. CO-ORDINATION CHEMISTRY

IV – 6 (elective) – – 2 –

The fundamental principles underlying co-ordination compounds: bonding, geometry and isomers, stability, etc., leading to an understanding of examples such as chlorophyll and sequestering agents.

J. G. Breckenridge

681. ENVIRONMENTAL ENGINEERING

IV – 6 (elective) – – 2 –

Principles and design procedures of air, water and soil pollution control processes, with emphasis on aqueous industrial waste treatment. Chemical, physical and biological approaches will be discussed. Field trips will be arranged.

D. Mackay, C. R. Phillips

682. CHEMICAL BONDING

IV – 6 (elective) – – 2 –

An extension of the principles encountered in the course in Inorganic Chemistry given to II Year Course 6; a more detailed study of the chemistry of the elements.

R. L. Hummel

683. NUCLEAR ENGINEERING

IV – 6 (elective) – – 2 –

Nuclear engineering aspects of: nuclear constitution and properties including cross-section, energetics, radioactivity, production and use of radio-isotopes, neutrons, slowing-down, diffusion of thermal neutrons, fission. Applications of heat transfer to the reactor core; measurement and control of radiation, exposure of humans to radiation, shielding techniques.

D. G. Andrews

684. INTERFACE KINETICS

IV – 6 (elective) 2 – – –

A course on the chemical kinetics of catalytic processes and the design of chemical reactors.

W. F. Graydon

DEPARTMENT OF ELECTRICAL ENGINEERING

700. ELECTRICITY

I – 1, 3, 4, 6, 7, 8, 9 2 ¾ 2 ¾

A basic course in electricity and magnetism including electric forces and fields, analysis of direct-current circuits, magnetic forces and fields, induction, and an introduction to the conductive, magnetic and dielectric properties of materials.

Staff in Electrical Engineering

701. ELECTRICITY

I – 5 2 – 2 –

A basic course in electricity and magnetism that is similar to subject 700 but adapted to the needs of Course 5.

Staff in Electrical Engineering

710. CIRCUIT THEORY I

II – 7 3 2 – –

Linear lumped-parameter circuits as models for physical devices; relationships between circuit and field concepts. Transient response of simple circuits; natural and forced components of response. Response to complex-frequency excitation; impedance and admittance functions. Steady-state response of circuits with direct and sinusoidal sources.

711. ELECTRIC AND MAGNETIC FIELDS

II – 7 – – 3 2

Static electric and magnetic fields. Properties of dielectric and magnetic media. Particle dynamics in electric and magnetic fields. Time-varying fields. Development of Maxwell's equations and interpretation.

712. CIRCUIT THEORY II

II – 7 – – 2 2

Loop and nodal analysis. General network theorems. Coupled circuits. Response of networks to variable-frequency excitation. Analysis of polyphase circuits; introduction to symmetrical components.

713. ELECTRICAL LABORATORY

II – 7 – 3 – –

Introduction to techniques of electrical measurement.

714. INTRODUCTORY ELECTRONICS

II – 7 – – 2 3

The broad application of semiconductor devices to common engineering systems; basic device characterization, modelling, amplification, waveshaping, switching.

715. ELECTRIC CIRCUITS

II – 5 2 1½ 2 1½

Circuits as models for physical devices. Kirchhoff's laws. Transient response of circuits. Steady-state response of circuits with sinusoidal excitation. Network theorems. Topology and loop and nodal analysis of general circuits. Complex frequency analysis of circuits. Response of circuits to variable-frequency excitation. Analysis of polyphase circuits. Magnetically coupled circuits.

717. CIRCUIT THEORY AND MEASUREMENTS

II – 3 3 3 – –

Introduction to linear circuit analysis. Phasor representation and the analysis of alternating current circuits in the steady state. Transducers for electrical measurement of non-electrical variables, and associated instrumentation.

719. ELECTRICAL ENGINEERING

II – 6 2 3 2 3

Analysis of single-phase and three-phase circuits; principles of a-c and d-c machines; introduction to vacuum-tube and solid-state devices; basis of digital computation and analogue simulation; electronic measurements applied to industrial processes.

721. NUMERICAL METHODS

II – 7 – – 2 2

Elementary numerical methods for systems of equations, iteration, integration, differential equations, roots, and random number generation, including a study of roundoff and truncation error. Basic computer structure and organization. Algorithms, procedures, and flowcharts. Discrete simulators and continuous simulators.

722. ELECTRICAL ENGINEERING

II – 4 – – 3 3

A course similar to 719 but adapted to the needs of students in Industrial Engineering.

730. PHYSICAL ELECTRONICS I

III – 7 2 1½ – –
III – 8 2 ¾ – –

The prime objective of 730 and 731 is to provide a sound physical understanding of phenomena and devices in modern electronics. Circuit models of devices are developed from the mathematical models which describe the basic device physics. Band theory of solids: Fermi-Dirac statistics. Metals, semiconductors and insulators: thermionic emission, Schottky effect and high field emission with examples. Contact potentials. Semiconductor theory: band structure of Ge, Si and III-V compound semiconductors. Intrinsic and extrinsic semiconductors: general calculation of the Fermi level, hole and electron densities. Mobility, conductivity and their temperature dependence. Diffusion. The continuity equation and its solution. Theory of p-n junctions; minority carrier injection, basic equations. Depletion and diffusion capacitances. Circuit models. Other diode structures: tunnel diodes, Schottky barrier diodes, Gunn diode.

731. PHYSICAL ELECTRONICS II

III – 7 – – 2 1½

Unipolar transistors: basic types: junction-gate, M.I.S., and thin-film F.E.T.'s theory, circuit models. Bipolar transistors: fundamental theory, injection efficiency, base transport efficiency, small-signal low-frequency models. Charge storage models. High-frequency, small-signal analysis and circuit models. Fundamentals of integrated circuits: fabrication theory and technology: diffusion, epitaxy, oxide masking: capacitors, resistors, bipolar and unipolar transistor integration. Examples. Photoelectronics solid-state optoelectronic phenomena: photoconductive, photovoltaic and p-n junction radiation detection. Vacuum photoelectronics: image orthicon, vidicon, image storage and intensification.

732. APPLIED MATHEMATICS I

III – 7 2 2 – –

Theory of functions of complex variables, with applications.

733. LINEAR SYSTEMS THEORY

III – 7 4 2 – –

Correlation with orthogonal functions as a method of signal transformation. Fourier series, generalized Fourier and bilateral Laplace transforms; existence, uniqueness, and properties. Time-domain analysis; weighting functions, convolution, convolution algebra, similarity of correlation and convolution. Frequency-domain analysis; transfer functions, filter characteristics, pole-zero configurations. Frequency-domain convolution; time-varying systems and modulation. Matrix methods for multiple input-output systems; theory of linear two-port networks.

734. ELECTROMECHANICAL SYSTEMS I

III – 7 2 3 – –

Processes of electromechanical energy conversion; modelling and analysis of magnetic devices and systems; transformers and saturable reactors; commutator machines.

735. ELECTROMECHANICAL SYSTEMS II

III – 7 – – 2 3

Generalized polyphase machines; induction and synchronous machines; introduction to the control of electric machine systems.

736. APPLIED MATHEMATICS II

III – 7 – – 3 2

Introduction to Modern Algebra. Elementary theory of probability and stochastic processes.

737. ELECTRONIC CIRCUITS I

III – 7 – – 2 3

P-N junction diode models: advanced applications of p-n junction diodes. Temperature dependence of diode characteristics and methods for compensation. Amplifiers, specifications, general methods of design. Field-effect transistors: characteristics, biasing, amplifiers, voltage controlled resistance. Bipolar transistors: basic concepts, fabrication: power gain: basic configurations: Ebers and Moll model: circuit models: single and multistage amplifiers. Switching properties; feedback amplifiers: oscillators. Narrow and wide band amplifiers. Power amplifiers. Integrated circuit design techniques.

739. PHYSICAL ELECTRONICS

III – 5cs, 5e, 5m, 5p 2 1 2 1

The objective of this course is to provide a sound understanding of physical phenomena associated with semiconductor devices. Band theory of solids. Metals, semiconductors, insulators. Thermionic emission, contact potential. Semiconductor theory. Schottky barrier (hot carrier) diodes. P-n junctions, Read diode, tunnel diode. Bipolar transistors. Field effect transistors, MOS transistor. Unijunction transistor. Fundamentals of integrated circuits. Photoelectronics: image orthicon, vidicon, image storage.

740. ELECTRONICS

III – 5a, c, cs, eg, p 2 – 2 1½

Qualitative treatment of the physical principles of electron devices; analysis of idealized and basic practical rectifying and power-modulating circuits; some applications to systems.

743. ELECTRONICS

III – 3 2 3 – –

Principles of electronics. Linear models of electronic devices. Amplifiers, oscillation and filters. Electronic circuits.

744. SYSTEM AND SIGNAL ANALYSIS

III – 5e 2 1½ – –

Formulation of system models. Linear system theory from state space and from input-output points of view. Signal representations. Integral transforms and their applications to signal and system analysis.

747. ELECTRIC MACHINES

III – 3 – – 2 3

Principles of energy conversion. Transient operation of electromechanical systems. Electromechanical circuits. Rotating machinery.

750. FIELDS AND WAVES

III – 7 2 2 – –

Propagation of plane waves. Reflection of waves at plane boundaries. Guided waves. Transmission line theory. Smith chart. Radiation from antennas. Diffraction and scattering. Introduction to holography.

751. THERMODYNAMICS AND STATISTICAL MECHANICS

II – 7 – – 3 1

The fundmental principles of thermodynamics and statistical mechanics; Boltzmann, Fermi-Dirac and Bose-Einstein distributions and their applications to electric, magnetic and electromagnetic systems; elementary theory of fluctuations.

754. ELECTROMAGNETIC FIELDS

III – 5cs; IV – 7 (elective) 2 1 – –

Relation between field theory and circuit theory. Maxwell's equations. Unbounded field systems. Boundary conditions for time-varying fields. Plane waves in dielectric media. Phase and group velocity. Standing waves. Poynting vector. Energy relations in travelling and standing waves. Wave polarization. Plane waves in conducting media. Depth of penetration. Reflection and transmission of waves at a boundary. Transmission lines. Terminated uniform transmission lines. Transmission-line charts. Waves in infinite-parallel-plane transmission line. Modes in hollow rectangular waveguide. Antennas. Retarded potentials. Small Loop Antenna. Short Dipole Antenna.

760. SWITCHING THEORY

III – 5cs; IV – 7 (elective) 2 1 – –

Boolean algebra, boolean functions, combinational networks, minimum complexity combinational networks, Karnaugh and Quine-McCluskey minimization. Sequential machines state assignment, state reduction, relationship to switching components. The problems period will provide exercises in logic and sequential machine analysis and synthesis.

761. INFORMATION PROCESSING SYSTEMS I

IV – 7 (elective) 2 1 – –

Number representation: Binary number system, representation of negative numbers, binary arithmetic. Computer architecture: basic hardware structure, registers, memory system, addressing, instructions, 1/0. Programming languages; machine language programming, basic and macro assemblers, compilers. (PL/1, Algol. simulators). Programming systems: data structures, properties of data types, syntax structures, parsing, symbol tables. The problems period will include exercises in programming in 360 assembly language and in a variety of high level languages.

762. ELECTROMAGNETIC THEORY

IV – 7 (elective) 2 1 – –

Wave polarization. Rectangular and circular waveguides. Uniqueness of solutions. Wave propagation in the ionosphere. Radiation from wire antennas, simple arrays and continuous current distributions. Fields and impedance of a current-carrying conductor. Concepts of impressed, induced and equivalent sources. Reciprocity. Calculation of self and mutual impedance.

763. UNIFIED MACHINE THEORY

IV – 7 (elective) – – 2 1½

The theory of linear passive power invariant transformations is developed. Electromagnetic devices will be presented by flux linkage models which are then modified by various generalized transformations in order to facilitate their representation in systems requiring transient and steady state stability studies. A generalized co-ordinate transformation system for an m-n phase system revolving with respect to any arbitrary reference frame is developed and this is then reduced to the more classical phase, dq, or symmetrical component models. Evaluation of system parameters required for the models will be discussed.

764. ELECTRICAL SYSTEMS

IV – 8 2 – – –

Electrical heating and melting. High temperature and vacuum applications. Controls. Instrumentation. Sensors. Transducers. Automation. Feedback. Logic circuits and computers.

765. CONTROL SYSTEMS I

IV – 7 3 1½ – –

Open-loop and closed-loop control; feedback systems. Flow-graph analysis of complex systems. Steady-state performance analysis. Stability analysis for linear time-invariant systems; algebraic, real-frequency, and root-locus methods. Design of single input-output controls. Elementary nonlinear analysis.

766. SYSTEM DYNAMICS

IV – 5e, 5p 2 1½ – –

A study of the dynamic behaviour of systems, using the techniques of state representation, Laplace and Z transforms, frequency-response and root-locus methods. Introduction to feedback control systems. Stability and compensation of linear and non-linear control systems.

767. INTRODUCTION TO OPTIMAL CONTROL

IV – 5e – – 2 –

An introduction to the calculus of variations, the maximum principle and dynamic programming, as they apply to the optimal control of systems. Introduction to computational methods of optimization.

768. ELECTRONIC CIRCUITS II

IV – 7 2 3 – –

Design of semiconductor circuits emphasizing bias stabilization, feedback d-c amplifiers, broadband amplifiers, tuned amplifiers and large signal applications.

770. COMMUNICATION SYSTEMS

IV – 7 (elective) – – 2 3

A book is recommended as follows: "Communication Theory Principles" by Charles W. McMullen.

Initial material amplifies the role and properties of the Fourier integral and the double sided Laplace transform as a means of describing communication signals and systems. Early attention is paid to the synthesis of desired input output relationship by means of feedback circuits and by means of the transversal filter techniques.

The next topics are modulation and sampling, the convolution theorems, Nyquist (1928) band-limited signaling, sampling theory, and vestigial side band transmission. Elementary probability and statistical theory is introduced next to support the fundamental ideas of information theory, noise in electronic circuits, and random signals.

772. NETWORK THEORY

IV – 7 (elective) 2 1 – –

Network analysis. One-port and two-port network parameters, and their relation to determinants of network equations. Natural frequencies. Transfer functions of two-ports. Interconnections of two-ports. Energy functions. Properties of network functions. Synthesis of LC, RC and RL one-ports. Positive real functions. Testing for positive realness. The Froster preamble. Brune realization. Brief treatment of Bott-Duffin and Miyata realizations. Properties of general passive two-port functions, balanced and unbalanced two-ports with and without magnetic coupling, and lossless two-port functions. Magnitude and angle functions. Minimum-phase and all-pass functions. Realization of lossless singly – and doubly – terminated two-ports.

774. INTEGRATED CIRCUITS

IV – 7 (elective) – – 2 1½

Design of integrated circuits with particular emphasis on the interaction between device and circuit design. Thin film and semiconductor integrated circuits. Design of integrated circuit components: capacitors, resistors, inductors, diodes, transistors. Linear and digital integrated circuit design techniques and limitations.

775. SEMICONDUCTOR PHYSICS

IV – 7 (elective) 2 1½ – –

Selected topics in important physical concepts, allied to a deeper understanding of the properties of semiconductors, comprising: Crystal structure and crystal binding. Elastic waves. Phonons and lattice vibrations. Thermal properties. Theory of metals. Band theory applied to semiconductors. Semiconductor carrier concentrations and transport.

776. RADIATION AND PROPAGATION

IV – 7 (elective) (prerequisite – 762) – – 2 1½

Microwave amplifiers and oscillators. Microwave components. Antenna arrays. Microwave communication systems. Formal solution of boundary value problems; Green's functions. Scattering by conductors. Diffraction by apertures. Fourier optics and holography. Spherical-earth propagation.

777. QUANTUM PHYSICS

IV – 7 (elective) 2 1½ – –

Development of Schroedinger equation and its application to simple models of atomic systems. Zeeman effect, angular momentum and electronic spin. Pauli principle and electron theory of atomic structure.

778. ELECTRONIC CIRCUITS

IV – 5a, 5cs, 5e, 5p 2 3 – –

Design of electronic circuits. Multistage amplifiers. Feedback amplifiers. Oscillators. DC amplifiers. Wideband amplifiers. Tuned amplifiers. Mixers. Detectors. Active filters. Negative impedance converters. Gyrators. Introduction to computer design of electronic circuits.

779. POWER SYSTEM ANALYSIS

IV – 7 (elective) 2 1½ – –

Engineering criteria for generation, transmission and distribution of electrical energy in bulk. Characteristics of components and their significance to power system safety, reliability and economy. Behaviour of elementary power systems under normal and fault conditions.

780. POWER SYSTEM CONTROL

IV – 7 (elective) – – 2 1½

Economic management of electric power system operation. Methods for determination of load flows. Economic scheduling of generating plants. Basic concepts of load frequency control. Analysis of power system dynamical performance including the effects of generator controls.

781. APPLIED MATHEMATICS III

IV – 7 (elective) 2 1 – –

Partial differential equations and the calculus of variations.

782. INFORMATION SYSTEMS I

IV – 5cs, 5e 2 1 – –

Probability theory, probabilistic formulation of the communication problem, representation of physical communication channels, Gaussian noise process, power spectrum, correlation function, vector model of a communication channel, error rate estimates, channel capacity theorem, analogue digital analogue conversion techniques, coding for transmission in noise. Text – Principles of Communication Engineering – Wozencraft and Jacobs.

784. QUANTUM ELECTRONICS

IV – 7 (elective) (Prerequisite – 777) – – 2 1

Theory of radiation absorption and emission; susceptability, population inversion and maser action. Maser and laser materials and device properties, limitations and use of the devices; nonlinear behaviour of materials at optical frequencies.

786. INFORMATION SYSTEMS II

IV – 5e – – 2 3

A study of the transmission and processing of digital information: Information sources; exponential error bounds and capacity theorems for coding and waveform channels; block and convolutional coding.

787. TECHNIQUES OF OPTIMIZATION

IV – 5cs, 5e – – 3 2

Linear and non-linear mathematical programming; dynamic programming; queueing theory; some problems in control theory; Monte Carlo methods. Applications will be drawn from engineering practice.

790. WAVE THEORY

IV – 5e, 5p 2 1½ – –

Guided TE, TM and TEM waves. Attenuation of guided waves. Coaxial, stripline and microstrip TEM lines. TEM lines as circuit elements. Variational and conformal mapping techniques for determining characteristic impedances of TEM lines. Smith chart. Propagation in rectangular and circular waveguides. Inhomogeneously filled waveguides. Discontinuities in waveguides. Transients in waveguides. Periodic structures. Radiation. Antenna fundamentals. Antenna arrays. Measurement techniques.

792. ACOUSTICS

IV – 7 (elective) – – 2 1½

The physical and psychological nature of sound. The production, detection, and measurement of physical sound. Relationships between physical sound signals and psychological experiences. The behaviour of sound outdoors and indoors. Engineering criteria for noise and vibration. Tests, standards, and codes. Noise control methods.

V. L. Henderson

793. CONTROL SYSTEMS II

IV – 7 (elective) – – 2 1

State representation of dynamic systems. Vector-matrix differential and difference equations as descriptions of linear systems. Eigenvalues, eigenvectors, and transition matrices. Controllability and observability. Introduction to optimization. Emphasis throughout on the use of analog and digital computers as aids to analysis and synthesis.

794. ILLUMINATION

IV – 7 (elective) – – 2 1½

The course deals in general with the engineering problems which relate to the effective use of light (physical, physiological and psychological) in the everyday life of man. The topics covered include: The nature and characteristics of light; The production of light: incandescence and luminescence; The human eye, visual processes, and visual phenomena; Radiometric and photometric units and laws; Photometric measurements; Calculation of photometric quantities; Design of the visual environment: principles which relate to visual comfort and efficiency; Colour and colorimetry; Light sources – circuits and controls; Visual problems at low light levels e.g. street lighting. The laboratory supplements the theoretical material of the lecture course.

Miss M. G. Currie

795. POWER SEMICONDUCTOR CIRCUITS

IV – 7 (elective) – – 2 1½

Principles of thyristor devices. Study of inverter, converter and rectifier circuits with particular applications to DC and AC motor speed control and frequency conversion.

796. BIOMEDICAL ENGINEERING

IV – 7 (elective) – – 2 1½

An introduction to some aspects of the interaction between engineering and medicine, given by the staff of the Institute of Bio-Medical Electronics and Engineering: Basic Anatomy and Physiology; Biological communication processes; Biological feedback and control; Bio-medical instrumentation; Cardiovascular measurements; Radiation diagnosis. The course is accompanied by laboratory experiments.

797. ELECTRODYNAMICS

IV – 5a, 5e, 5p, 7 (elective) (Prerequisite – 762 or equivalent) – – 2 1½

Maxwell's equations and constitutive relations in different media. Linear and nonlinear media. Coupled mode approach. Field theory approach. Dispersion relation theory: causality, stability, group and phase velocity. Wave/particle interactions: travelling wave tube, klystron, backward wave oscillator, beam/plasma interaction, acoustic wave interactions, interactions in semiconductors. Wave/wave interactions: parametric interactions, optical amplifiers. Nonlinear wave/particle interactions. Relativistic electrodynamics.

798. INFORMATION PROCESSING SYSTEMS II

IV – 7 (elective) (Prerequisite – 761) – – 2 1

Computer organization: register implementations, register transfers, memory, control unit logic, instruction processing logic, execution unit, simple implementations of arithmetic operations. Programming languages; some advanced concepts of applications and systems programming in both business and scientific areas. Formal languages and machines: finite state language and automata, formal grammars, context free languages and their relation to programming languages, Turing machines. The laboratory session will include problems in 360 assembly language programming based on the course.

799. SWITCHING CIRCUITS

IV – 5cs, 5e, 7 (elective) – – 2 1½

Large signal modelling of nonlinear circuit elements; analysis of static and transient circuit behaviour; use of time-domain circuit simulation. Design to specification with imperfect components – worst case and statistical approaches to reliable design. Application to solid state switches, multivibrators and networks of cascaded gate circuits. Signal transmission methods. Integrated circuit technology. Physical phenomena applicable to memory functions – ferromagnetics, cryogenics, electrostatics, photochromics, acoustics. Address selection principles. Universal requirement for high-current switches and sense amplifier design. Techniques for improving signal-to-noise performance.

Note: An elementary knowledge of switching theory will be assumed. This may be obtained from Course 760 – Switching Theory, or by self study.

DEPARTMENT OF METALLURGY AND MATERIALS SCIENCE

802. EXTRACTIVE METALLURGY

III – 8 2 – 2 –

A fundamental treatment of the metallurgical processes involved in the production of the important non-ferrous metals, including oxidation of sulphides in the liquid and solid states, reduction of oxides, matte-slag equilibrium, metal-slag equilibrium, and the distillation of metals.

H. U. Ross, J. M. Toguri

803. EXTRACTIVE METALLURGY LABORATORY

III – 8 –3–3

Experiments in materials processing, including roasting, smelting, leaching, refining, electrolysis to accompany Course 802. Eight laboratory reports per term.

H. U. Ross

804. EXTRACTIVE METALLURGY

III – 9 2–2–

The metallurgical processes involved in the beneficiation of ores and the extraction of metals therefrom and their subsequent refinement.

L. M. Pidgeon, H. U. Ross

805. EXTRACTIVE METALLURGY

IV – 8 2–2–

The extractive metallurgy of iron, steel, and the reactive metals.

C. B. Alcock, H. U. Ross, J. M. Toguri

806. EXTRACTIVE METALLURGY LABORATORY

IV – 8 –3–3

Experiments in the extraction and refining of metals and related processes to accompany subject 805. Six laboratory reports per term.

C. B. Alcock, H. U. Ross, J. M. Toguri

807. SOLID STATE CHEMISTRY

II – 8 22––

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber cycle and replacement reactions. Point defects, non-stoichiometry and conductivity. The Schroedinger equation and its solution in terms of orbitals. Bonding in condensed phases.

C. B. Alcock

808. INSTRUMENTAL ANALYSIS

II – 8 –––3

The analysis of ores, concentrates, slags and alloys employing the techniques of wet analysis, polarography, electrogravimetry and spectroscopy.

H. U. Ross

809. MINERAL DRESSING

III – 8 (elective) ––2–

The theory and practice of minerals beneficiation, including relevant aspects of mineralogy, surface chemistry and flotation, physical separation and leaching processes.

H. U. Ross

810. THERMODYNAMICS

III – 8 2 – 2 –

A study of chemical equilibria at high temperatures in extractive metallurgy – slag metal reactions – classical theory of solutions – phase transformations – thermodynamic relationships in phase diagrams.

H. U. Ross

812. METALLURGICAL PROBLEMS LABORATORY

III – 8 – 4 – 2

Problems in chemistry, physical chemistry and thermodynamics as applied to metallurgical processes, and solid state reactions relating to subjects 802 and 810.

S. N. Flengas, H. U. Ross

813. ELECTROCHEMICAL PROCESSES

IV – 8 – – 2 2

Electrochemistry of solids, liquids, and of high temperature systems. Fused salt electrochemical cells. Thermodynamics of imperfections and properties of ionic solids.

S. N. Flengas

814. METALLURGICAL PROBLEMS LABORATORY

IV – 8 – 3 – 3

Problems relating to courses 805, 815 and 823.

Staff in Metallurgy and Materials Science

815. MATERIALS SCIENCE

IV – 8 – – 3 –

Structures and properties of interfaces, recovery and recrystallization, annealing textures and anisotropic properties. Solidification and casting, growth of single crystals and zone refining.

K. T. Aust, J. W. Rutter

817. STRUCTURE OF MATERIALS AND METALLOGRAPHY

II – 8 2 3 – –

A course dealing with both the theoretical interpretation and the experimental determination of the structure of solids. Structure is discussed in terms of crystallography, defects in crystals, amorphous materials, polycrystalline grain structure and phase distribution in alloys. Metallographic techniques for the determination of microstructure by optical, x-ray, electron and field-ion microscopy are considered, as are the introductory principles of x-ray diffraction.

U. M. Franklin, W. A. Miller

819. MATERIALS SCIENCE I

II – 7 3 1½ – –

The thermal, mechanical and chemical properties of materials will be related to their microscopic structure. Atomic bonding, crystal structure (with special emphasis on Group IV and Group III–V semiconductors): Thermodynamics of solids, defects. Solid-state diffusion. Phase diagrams, phase transformations with examples. Single crystal growth. Mechanical properties: stress, strain and shear relations for isotropic and anisotropic materials; annealing, structural materials; fabrication processing. Corrosion.

J. W. Rutter

820. SOLID STATE SCIENCE

III – 5m, 8 2 – – –

Diffusion in solids. Phase stability and alloy theory. Magnetic, electrical and optical properties of materials.

U. M. Franklin

821. PLASTIC DEFORMATION AND MECHANICAL PROPERTIES

III – 5m, 8 – – 2 –

Plastic deformation and the mechanical properties of materials are discussed in terms of dislocation theory. Slip and twinning, work hardening and other strengthening mechanisms, and the processes of creep and fatigue are some of the most important topics considered.

B. Ramaswami

822. PHYSICAL METALLURGY LABORATORY

III – 5m, 8 – 3 – 3

An introductory series of experiments dealing with annealing and recrystallization, plastic deformation and mechanical properties, and the use of metallographic, x-ray and non-destructive testing methods.

U. M. Franklin, W. A. Miller

823. PHYSICS OF METALS

IV – 5m, 8 3 – – –

Application of thermodynamics and kinetics to solid state phase transformations, theory of martensitic transformations, structures and properties of ferrous materials.

G. B. Craig, G. C. Weatherly

824. PHYSICS OF METALS LABORATORY

IV 8 – 3 – –

Practical work relating to subject 823.

G. B. Craig, G. C. Weatherly

825. MATERIALS SCIENCE LABORATORY

III – 8 (elective) – 3 – –

Projects in materials science, chosen by the student, and carried out in close consultation with the staff.

B. Ramaswami

826. POWDER METALLURGY

IV – 8 (elective) – – 2 –

Production and agglomeration of powders, the theory and practice of sintering, and the application of powder methods in the production of refractory metals, cemented carbides and other materials.

Staff in Metallurgy and Materials Science

827. MATERIALS SCIENCE LABORATORY

IV – 5m ‒ ‒ ‒ 6

The design and execution of one or more experiments on a topic of current interest in the field of chemistry and physics of materials.

Staff in Metallurgy and Materials Science

828. PHYSICAL METALLURGY PROJECT

IV – 8 (elective) ‒ ‒ ‒ 3

A laboratory project in physical metallurgy relating to course 823.

G. B. Craig

829. EXTRACTIVE METALLURGY PROJECT

III – 8 ‒ ‒ ‒ 3

A laboratory project in extractive metallurgy relating to course 802.

H. U. Ross

830. METALLURGICAL THERMODYNAMICS

III – 5m 2 2 2 2

A study of chemical equilibria at high temperatures in metallurgy; slag metal reactions; chemical theory of solutions; alloys; phase transformations; thermodynamic relationships in phase diagrams; statistical concept of entropy; simple partition functions; quasichemical approach to the theory of solutions; methods of investigating thermodynamic properties.

S. N. Flengas

832s. MATERIALS SCIENCE

II – 8 ‒ ‒ 3 ‒

A course on the structure and properties of plastics, glass, ceramics, semi-conductors, and concrete.

Staff in Chemical Engineering, Civil Engineering, Electrical Engineering, Metallurgy and Materials Science

834. MATERIALS SCIENCE

II – 4 3 3 ‒ ‒

A discussion of the effects of microscopic and atomic structures on the electrical, chemical and mechanical properties of engineering materials. The topics covered include atomic bonding, structures of ideal and real crystals, phase transformations and diffusion, chemical and mechanical properties, and oxidation and corrosion phenomena. The laboratory experiments will include x-ray studies of crystal structure; measurement of resistivity and magnetism of selected solids; study of various alloy phases and transformations; study of dislocation patterns, stress-strain relationships, stress-relaxation and fatigue phenomena; study of oxidation and corrosion reactions.

B. Ramaswami

835. MATERIALS SCIENCE II

III – 7 – – 2 1½

The magnetic, dielectric and conductive properties of materials, as related to their structure, will be discussed. Magnetic properties: dia-, para-, ferro-, antiferro-, and ferri-magnetic phenomena; magnetic domains and domain wall motion; "hard" and "soft" magnetic materials; magneto-striction. Dielectric materials: insulating properties; conduction mechanism; dielectric loss. Ferroelectric materials. Electrical conduction: temperature dependence; effect of composition and structure on conductivity. Thermoelectric phenomena.

U. M. Franklin

836. REACTION KINETICS

IV – 8 2 2 – –

Kinetics of heterogeneous reactions. Diffusion controlled processes. Imperfections in solids. Fick's laws of diffusion. Application of theory to metallurgical operations.

J. M. Toguri

837. MATERIALS SCIENCE

II – 3 2 – 2 1½

A discussion of the effects of microscopic and atomic structures on the properties of engineering materials. The topics covered include atomic bonding and structures of materials, diffusion, crystal growth and solidification, plastic deformation and annealing, precipitation hardening, phase transformations especially in ferrous materials, relationships between structures and mechanical properties of metallic and non-metallic materials, and composite materials.

The laboratory experiments are designed to illustrate the principles underlying the relationship between structures and properties of engineering materials.

K. T. Aust

838. MATERIALS SCIENCE

III – 5m 2 – 2 –

A course on the structures and properties of materials, particularly non-metallic inorganic solids.

W. A. Miller, G. C. Weatherly

839. MATERIALS SCIENCE

IV – 5m 2 3 2 3

A continuation of course 838 with emphasis on physical and mechanical properties of materials; high-purity and composite materials. The laboratory work deals with experimental studies of the relationship between structures and properties of materials. Application of x-ray, electron microscopy, electron diffraction, electron microbeam techniques to the study of materials.

K. T. Aust, J. W. Rutter

841. THEORY OF METALLURGICAL REACTIONS

IV – 5m 2 – – –

Metal extraction and refining processes are examined in terms of chemical thermodynamics and kinetics. The principles and methods of extraction of ferrous and non-ferrous metals, roasting, leaching and electrowinning are typical of the subjects discussed.

J. M. Toguri

842. HIGH TEMPERATURE PHYSICAL CHEMISTRY

IV – 5m **2 3 2 3**

Properties of solids and liquids at high temperatures; thermodynamics of defects; solid oxide electrolytes; mechanism of electrical conductivity in ceramic phases; fused-salt electrolytes; reactions in fused-salt media; electrochemical cells at high temperatures; fuel cells; structural properties of simple and complex liquid phases; electrochemical corrosion and passivation; kinetics of heterogeneous reactions.

S. N. Flengas

INSTITUTE FOR AEROSPACE STUDIES

1028. FLUID MECHANICS

III– 5a **2 – 1 –**

Introductory concepts and idealizations of real fluids; mathematical theory of incompressible inviscid flow; viscous flow and turbulence. Reference books: *Fundamentals of Hydro and Aeromechanics* – Prandtl and Tietjens; *Applied Hydro and Aeromechanics* – Prandtl and Tietjens; *Fluid Dynamics* (1948 ed.) – Streeter. Advanced reading: *Hydrodynamics* – Lamb; *Incompressible Aerodynamics* – Thwaites.

J. W. Locke

1029. FLUID MECHANICS LABORATORY

III– 5a **– 3 – 1½**

Problems and experiments related to subject 1028. Seven laboratory reports.

J. W. Locke, J. B. French

1030. MECHANICS

III – 5a, 5e, 5g, 5m, 5nt, 5p **2 – 2 –**

Kinematics, translations and rotation, reference frames. Dynamics of a particle and of a system of particles. Work, energy momentum. Linear oscillator. Simple pendulum (nonlinear). Kepler problem. Collisions. Lagrangian mechanics, generalized co-ordinates, Hamiltonians, constraints. Rigid bodies; kinematics, inertia, matrix, Euler's equations, torque-free motion, stability, geometrical insights. Vibrations: matrix formulation, characteristic modes and frequencies. Hamilton's principle.

Topics selected by class from: astrodynamics, Hamiltonian mechanics, special relativity, continuous media, and others.

Reference Books: *Principles of Dynamics*, Greenwood Classical Mechanics, Goldstein.

P. C. Hughes

1034. MECHANICS OF STRUCTURES

III – 5a **2 – 2 –**

Basic theorems and principles in the theory of structures (strain energy, virtual displacements, minimum total potential energy). General theory of bending of beams (unsymmetrical bending, thin walled structures, shear flow in multiflanged beams, open and closed sections). General theory of torsion (thin walled structures, multi-cell structures, shear centre). Theory of elastic instability (buckling of slender elastic struts, flat and curved plates, shells). Plane stress problems (Airy and Prandtl stress functions).

R. C. Tennyson

1035. MECHANICS OF STRUCTURES LABORATORY

III – 5a   – 1½ – 3

Problems and experiments relating to subject 1034. Five laboratory reports.

R. C. Tennyson

1040. AERODYNAMICS

IV – 5a   2 – 2 –

Aerodynamics of flight: drag, propulsion, wing theory. Mechanics of flight: performance of aircraft, stability and control of aircraft. Reference books: *Aerodynamics of V/STOL Flight* – B. W. McCormick, Jr. *Foundations of Aerodynamics* – Kuethe and Schetzer. *Flight Mechanics – 1: Theory of Flight Paths* – A. Miele. *Dynamics of Flight – Stability and Control* – Etkin.

J. H. DeLeeuw

1041. AERODYNAMICS LABORATORY

IV – 5a   – 1½ – 1½

Problems and experiments related to subject 1040. Six laboratory reports.

J. H. DeLeeuw

1042. PHYSICS OF RADIATING GASES

IV – 5a   2 – 2 –

Review of atomic and spectroscopic theory, line radiation, Einstein coefficients, optical depth, population inversion and lasers, Doppler and pressure broadening, vibration and rotation of molecules, local thermodynamic equilibrium, methods, of determining the temperature and electron number density of high temperature gases.

R. M. Measures

1043. PHYSICS OF RADIATING GASES LABORATORY

IV – 5a   – 1½ – 1½

Probe and spectroscopic studies of a low pressure discharge. Three laboratory reports.

R. M. Measures

1044. PHYSICS AND MECHANICS OF SOLIDS

IV – 5a   2 – 2 –

Properties of solids, the factors on which they depend. Structural imperfections, atom movements, dislocation theory. Deformation and failure of metals. Metal fatigue, service loads and service load laboratory simulation, statistical evaluation of fatigue data. Microstructural changes in metal due to fatigue, fatigue damage accumulation, crack initiation and propagation. Environmental effects on service life under fatigue, surface protection. Reference books: *Elements of Materials Science* – Van Vlack. *Inelastic Behaviour of Engineering Materials and Structures* – Freudenthal.

G. K. Korbacher

1045. PHYSICS AND MECHANICS OF SOLIDS LABORATORY

IV – 5a – 1½ – 1½

Problems and experiments related to subject 1044. Six laboratory reports.

G. K. Korbacher

1046. PLASMADYNAMICS

IV – 5a 2 – 2 –

Electrostatics, magnetostatics, Maxwell's equations, E-M wave propagation, plasma equations of motion and conduction, MHD approximation, tensor conductivity, Alfvén, magnetoacoustic and MHD shock waves, simple flow problems in magnetogasdynamics, applications to propulsion and power generation. Reference books: *Engineering Magnetohydrodynamics* – Sutton and Sherman. *The electromagnetogasdynamics of Fluids* – Hughes and Young. *Magnetofluidmechanics* – Cambel.

S. J. Townsend

1047. ENGINEERING DESIGN

IV – 5a – 6 – 3

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Drawings and reports are prepared as required.

L. D. Reid

1048. GASDYNAMICS

IV – 5a 2 – 2 –

The fundamental phenomena that occur in a flow of a compressible fluid are treated. The basic thermodynamics is reviewed and the equations of viscous and inviscid compressible flow are derived. Compressible flow in nozzles and diffusers, and shock and expansion waves in both steady and unsteady flow; and high temperature effects which cause departures from the perfect gas law are discussed. Applications relevant to modern high speed flight are given. Reference books: *Elements of Gasdynamics* – Liepmann and Roshko. *Dynamics and thermodynamics of Compressible Fluid Flow* – Shapiro. *Handbook of Supersonic Aerodynamics, Section 18, Shock Tubes* – Glass and Hall. *Introduction to Physical Gasdynamics* – Vincenti and Kruger.

I. I. Glass

1049. GASDYNAMICS LABORATORY

IV – 5a – 1½ – 3

Problems and experiments based on subject 1048 are given to illustrate principles of gasdynamics and the measurement of physical quantities. Six laboratory reports.

P. A. Sullivan

1050. TRANSPORT PHENOMENA

IV – 5a – – 2 –

A fundamental treatment of selected phenomena in fluid dynamics in which the transport of momentum, mass and energy are the key underlying processes, i.e. dynamics of viscous fluids; boundary layers; diffusion. Reference book: *Transport Phenomena* – Bird, Stewart and Lightfoot.

G. W. Johnston

DEPARTMENT OF PHILOSOPHY

2040. PHILOSOPHY AND SCIENCE

IV – All courses – – 2 –

Philosophical problems about space and time, focusing particularly on the debate between *absolutist* and *relativist* conceptions of both time and space, from Zeno and Aristotle to Einstein. Textbooks: *An Introduction to the Philosophy of Time and Space* – van Fraassen; *Problems of Space and Time (a reader)* – Macmillan 1964.

R. B. DeSousa

DEPARTMENT OF ENGLISH

2110. ENGLISH

I – All courses 2 – 2 –

This course is designed to teach students how to handle English tactfully and how to appreciate some basic forms of English literature. One part of the course will consist of laboratories held in class-time, where, through examples, the art and principles of good prose will be discussed, and students will be asked to write good prose in very short essays. The other part of the course will consider a novel, a play, and a few short stories and poems. The final mark will be awarded in part for the student's achievement in laboratories, and in part for his performance in an examination of the work studied.

2140. ENGLISH LITERATURE

IV – All courses 2 – – –

A course in the reading of literary works. Texts will include: Brecht, *Galileo* (Methuen); Williams, *A Streetcar Named Desire* (Signet); Beckett, *Waiting for Godot* (Grove); Golding, *Lord of the Flies* (Penguin); Heller, *Catch-22* (Dell); Crane, *The Red Badge of Courage* (Signet). Students are expected to read the works named above during the summer preceding their entry into the Fourth Year; further reading selections may be announced by individual instructors in September. Term work will include a class test on the summer reading to be given in the second lecture period of the year, one substantial essay or the equivalent, and one or two further class tests at the discretion of the instructor.

DEPARTMENT OF HISTORY

2330. THE HISTORY OF TECHNOLOGY AND ENGINEERING

III – All courses 2 – 2 –

An historical treatment of the development of tools, techniques, and relevant skills from their inception processes will be considered along with the interplay with contemporary society. Historical points of contact with theoretical and scientific thought will be examined. The accomplishments, influence, and role of the engineer will be traced from antiquity to current society.

J. W. Abrams

DEPARTMENT OF MATHEMATICS

2410s. ALGEBRA AND ANALYTIC GEOMETRY

I – 1, 3, 4, 6, 7, 8, 9 2 1 2 1

Vectors, linear algebra, matrices, solution of linear systems of equations, linear transformations, eigenvalues, linear programming, complex numbers, quadrics.

Staff in Mathematics and Staff in Engineering

2411s. CALCULUS

I – 1, 3, 4, 6, 7, 8, 9 2 1 2 1

Limits; derivatives, integrals and their properties with applications; circular and exponential functions and their inverses; differential equations.

Staff in Mathematics and Staff in Engineering

2415s. ALGEBRA AND GEOMETRY

I – 5 2 1½ 2 1½

Complex numbers and fields. Polynomials. Linear Algebra: linear equations, vector spaces and linear transformations. Co-ordinate Geometry: lines, planes and surfaces of the second degree.

P. A. Sullivan, L. T. Gardner

2416. CALCULUS

I – 5 2 1½ 2 1½

An introduction to the theory and applications of differential and integral calculus. Reference book: *Calculus*, Vol. I – Apostol.

P. Rosenthal, D. K. Sen

2420s. CALCULUS

II – 1, 3, 4, 6, 8, 9 2 1 2 1

Continuation of subject 2410. Partial differentiation, multiple integration, series and Taylor's theorem, complex numbers and hyperbolic functions, first order differential equations and higher order linear differential equations with constant coefficients.

J. Abrham, M. A. Akcoglu, K. Murasugi,
H. Radjavi, R. Van Luus

2421. CALCULUS II

II – 7 4 2 – –

The definite integral, expansion in series, ordinary differential equations, partial differentiation, multiple integration and an introduction to partial differential equations.

D. R. Breach

2422. PROBABILITY AND STATISTICS

II – 3 – – 3 1½

Elements of probability theory, random variables, binomial, Poisson and normal distributions, sampling distributions, tests of significance, control charts, introduction to the design of experiments.

D. B. DeLury

2423. PROBABILITY AND STATISTICS I

II – 4, 8 2 2 2 2

Frequency distributions and probability laws; binomial, Poisson, and normal distributions and the treatment of samples drawn from them; tests of significance and confidence limits; control charts; introduction to the analysis of variance; design of experiments; regression theory.

M. S. Srivastava

2424. CALCULUS

II – 3 3 1½ – –

Continuation of subject 2410. Partial differentiation, multiple integration, series and Taylor's theorem, first order differential equations and higher order linear differential equations with constant coefficients.

2425. CALCULUS

II – 5 3 2 3 2

Ordinary and partial differentiation, differentials. Taylor's theorem for functions of one or more variables, maxima and minima, transformations, convergence and uniform convergence, differential equations of the first order, linear differential equations with constant coefficients, methods of indefinite integration, definite integrals, multiple integrals, line and surface integrals, orthogonal functions. Textbook: *Advanced Calculus* – Taylor.

C. Davis

2427. PROBABILITY AND STATISTICS

II – 5 3 2 – –

Definition of probability; binomial, Poisson, and normal distributions; frequency; sampling distributions. Examples of estimation, hypothesis testing, control charts, regression, and analysis of variance.

D. B. DeLury

2429. NUMERICAL METHODS

II – 5 – – 2 2

Non-linear equations, matrix calculations, quadrature, and ordinary differential equations.

E. V. Swenson

2430. PROBABILITY AND STATISTICS II

III – 4 – – 2 2

A continuation of course 2423. General regression theory; elements of the theory of sample surveys; an introduction to the theory of stochastic processes.

A. E. Paull

2432. DIFFERENTIAL EQUATIONS

III – 4, 8, 9 2 2 – –

First and second order ordinary differential equations, operational methods, variation of parameters, solution in series, Fourier series, Bessel and Legendre functions, the Laplace transform.

E. J. Barbeau

2433. NUMERICAL ANALYSIS I

III – 4 2 2 – –

Solution of algebraic equations, systems of linear equations, eigenvalue problems, interpolation, approximation theory, numerical integration, random numbers. Textbook: *Elementary Numerical Analysis* – S. D. Conte. Reference: *Modern Computing Methods* – E. T. Goodwin.

W. K. Hastings

2434. NUMERICAL ANALYSIS II

III – 4 – – 2 2

A continuation of course 2433.

W. K. Hastings

2437. THEORY OF FUNCTIONS

III – 5 2 – 2 –

Complex numbers, limits and series, analytic functions, Cauchy's theorem, Taylor and Laurent series, singularities and their significance, analytic continuation, contour integration, conformal mapping of one plane region on another. Textbook: *Introduction to Complex Analysis* – Nehari.

W. H. Greub

2438. DIFFERENTIAL EQUATIONS

III – 5 2 – 2 –

First order equations solvable by quadratures, the linear equation of general order, operator methods, simultaneous linear equations, Sturm-Liouville systems, numerical methods. Textbook: *Ordinary Differential Equations* – Birkhoff-Rota. References: *Special Functions of Mathematical Physics and Chemistry* – Sneddon; *Differential Equations with Applications* – Ritger and Rose. *P. A. Taylor*

2441. THE NUMERICAL SOLUTION OF INITIAL VALUE PROBLEMS

IV – 5cs 2 – – –

Solution of initial value problems for hyperbolic and parabolic partial differential equations. Difference schemes for nonlinear problems. Discontinuous solutions. Stability, consistency.

2442. THE NUMERICAL SOLUTION OF BOUNDARY VALUE PROBLEMS

IV – 5cs — – 2 –

Iterative solutions of large systems of linear equations. Difference approximations for elliptic boundary value problems; consistency, convergence. Mixed initial-boundary value problems of linear parabolic type; stability.

2443. NUMERICAL ANALYSIS

IV – 3 — – 2 –

Methods of solution of linear systems of equations, round-off errors, roots of equations, quadrature, approximations and rates of conversions, numerical solution of ordinary and partial differential equations. Exercises to be done on the computer will be assigned.

A. Sedgwick

2445. DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS

IV – 5 2 – 2 –

Equations of second order, Green's functions, distributions, Hilbert space, elements of functional analysis, eigenvalues and eigenfunctions with applications to wave propagation, heat flow and boundary value problems.

R. A. Ross

DEPARTMENT OF PHYSICS

2501. STRUCTURE AND PROPERTIES OF MATTER

I – 1, 2, 3, 4, 6, 7, 8, 9 2 1½ 2 1½

Conservation Laws for Particle Systems. Central Forces – Gravitational and Electrical. Thermodynamics. Waves – Mechanical and Electromagnetic. Relativity. Quantum Theory, the Atom, Complex Atoms. Solid State Physics. The Nucleus, and Nuclear Transformations. Elementary Particles. Text: *Essentials of Physics* – Borowitz and Beiser.

G. D. Scott, M. Trefler, E. C. West, T. S. Yoon

2511. ELEMENTS OF PHYSICS I

I – 5 3 1 2 1

Introduction to atomic and nuclear physics. Addition and multiplication of vectors with physical applications. Trajectories of particles. Rotational motion, conservation of angular momentum, moments of inertia, gyroscopes. Non-uniform accelerations, simple harmonic motion, resolution of complex simple harmonic motion. Reaction kinematics. Philosophy of conservation laws and symmetries. Gravitational and other natural forces.

Heat and thermodynamics, the laws of thermodynamics with physical applications. Ideal gases, kinetic theory, Maxwell-Boltzmann distribution of molecular velocities, specific heats of monatomic and polyatomic gases. Basic probability notions, postulates of statistical physics, entropy, absolute temperature, the canonical distribution.

Crystalline symmetry, elastic behaviour of solids. Dynamics of crystalline lattices, specific heats and solids, heat conductivity, thermal expansion.

K. G. McNeill

2512. PHYSICS LABORATORY I

I – 5 – 1½ – 1½

A loosely structured laboratory with a wide variety of experiments available. Individuality and ingenuity are encouraged.

K. G. McNeill

2521. ELEMENTS OF PHYSICS II

II – 5 3 1 2 1

Principle of relativity, Lorentz transformation, Einstein's special relativity, relativistic dynamics, space-time geometry, the electromagnetic field, analysis of a vector field. Matter in electrostatic and magnetostatic fields, electromagnetic field of uniformly moving charges, Maxwell's equations, radiation and its detection. Interference of electromagnetic waves, Huygen's principle and diffraction. Maxwell's equations in the presence of matter.

Classical systems and quantum systems. Wave-particle duality, Heisenberg uncertainty principle, electron and nuclear spin. Schroedinger equation. Eigenvalues and eigenfunctions. Transition probabilities. The harmonic oscillator. The hydrogen atom. Quantum aspect of electromagnetic radiation, quantum electrodynamics. Nuclear interactions, stable and unstable nuclei. Elementary particles – their production and interactions.

D. G. Ivey

2522. PHYSICS LABORATORY II

5 – 1½ – 1½

A loosely structured laboratory with a wide variety of experiments available. Individuality and ingenuity are encouraged.

D. G. Ivey

2531. STATISTICAL PHYSICS

III – 5a, 5cs, 5e, 5g, 5p – – 2 –

Kinetic theory of gases. Pressure and energy of a gas. Distribution of velocities. Transport phenomena. Review of basic concepts and formulas of thermodynamics. Statistical mechanics. Classical statistics of Maxwell-Boltzmann. Statistical thermodynamics. Monatomic gas. Equipartition theorem. Specific heat of diatomic gases. Quantum statistics: Bose-Einstein and Fermi-Dirac statistics. Laws of radiation. Electron gas. Fluctuations. Text: *Thermodynamics, the kinetic theory of gases and statistical mechanics* – Sears.

J. C. Stryland

2533. QUANTUM PHYSICS

III – 5a, 5cs, 5e, 5g, 5nt, 5p 2 – 2 –

Schroedinger's theory of quantum mechanics, perturbation theory, one-electron atoms, magnetic moments, spin and relativistic effects, identical particles, multi-electron atoms. Examples will be taken from atomic physics, molecular physics and to a smaller extent nuclear and particle physics. A core course. Text: *Fundamentals of Modern Physics* – Eisberg.

E. J. Allin

2534. PHYSICS OF SOLIDS AND FLUIDS

III – 5e, 5g, 5m, 5p – – 2 –

Kinematics of deformable bodies, elasticity, wave propagation, motion of ideal fluids, potential theory, Navier-Stokes equation, similarity.

J. V. Iribarne

2537. GEOPHYSICS

III – 5g 2 – – –

Physics of the earth, its atmosphere, magnetosphere; its evolution and processes taking place on it. An outline of the methods utilized in attacking current research problems is presented.

A. W. Brewer, D. York

2538. MOLECULAR AND SOLID STATE PHYSICS LABORATORY

III – 5g, 5nt, 5p – 3 – 3

The student may select a number of experiments in molecular and solid state physics from a list of available ones. The experiments are open-ended. The student may spend more or less time on any particular experiment depending on his interests. There is no set number of experiments required to obtain credit for the course.

A. D. May

2539. NUCLEAR AND PARTICLE PHYSICS LABORATORY

III – 5g, 5nt, 5p – 3 – 3

Nuclear physics experiments and experiments with slow and fast muons from cosmic rays are available. The experiments are open-ended. The student may spend more or less time on any particular experiment depending on his interests. There is no set number of experiments required to obtain credit for the course.

A. E. Litherland

2540. MOLECULAR AND SOLID STATE PHYSICS LABORATORY

III – 5a, 5e – 3 – –

The student may select a number of experiments in molecular and solid state physics from a list of available ones. The experiments are open-ended. The student may spend more or less time on any particular experiment depending on his interests. There is no set number of experiments required to obtain credit for the course. This course is the same as 2538 except one term only.

2541. NUCLEAR AND PARTICLE PHYSICS LABORATORY

III – 5a, 5e – 3 – –

Nuclear physics experiments and experiments with slow and fast muons from cosmic rays are available. The experiments are open-ended. The student may spend more or less time on any particular experiment depending on his interests. There is no set number of experiments required to obtain credit for the course. This course is the same as 2539 except one term only.

2542. PHYSICS SEMINAR

IV – 5p 2 – 2 –

The students will devise and carry out a seminar course on subjects of interest to them under the direction of a group of staff members. The course will only be given if a substantial number of students are interested.

J. M. Daniels, J. D. Prentice (coordinators)

2543. STATISTICAL MECHANICS

IV – 5p 2 – 2 –

Part I: Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics with applications. Elementary theory of irreversible phenomena.
Part II: Theory of imperfect gases, phase transitions. The Boltzmann equation, fluctuation theory and correlation functions. Text: *Fundamentals of Statistical and Thermal Physics* – Reif.

J. Van Kranendonk

2544. NUCLEAR PHYSICS

IV – 5nt, 5p 2 – 2 –

Nuclear forces. The properties of nuclei and their description by means of the shell model and the collective model. Electromagnetic interaction with the nucleus. Weak Interactions. The theory of nuclear reactions. The course will include some atomic and high energy physics in order to emphasize the important connections of both subjects with nuclear physics. Text: *Nuclear Theory* – Elton; *Nuclear Physics* – Roy and Nigam.

D. A. L. Paul, J. Goldenberg

2545. QUANTUM THEORY

IV – 5e, 5m, 5p 2 – 2 –

Waves and particles, wave packets, uncertainty principle. Schroedinger equation, expectation values, operators, eigenvalues, eigenfunctions, one dimensional problems. Angular momentum, central force problems, Pauli spin theory, identical particles, Pauli principle, applications to atoms and molecules. Zeeman effect. Perturbation theory, secular equations, time dependent perturbation theory, transition probabilities. Charged particles moving in electromagnetic fields, scattering theory.

J. W. Moffat

2546. SOLID STATE PHYSICS

IV – 5m, 5p 2 – 2 –

Free electron theory. Scattering from a rigid lattice. Pseudopotentials, band structure and Fermi surfaces. Electron-electron, interactions. Quasi-particles. Lattice vibrations. Electron-phonon interaction. Superconductivity. Semiconductors and P-N junctions. Diamagnetism and paramagnetism. Ferromagnetism and antiferromagnetism.

P. A. Griffin, E. Fawcett

2547. RELATIVITY THEORY

IV – 5p 2 – 2 –

Special theory: principle of relativity, Lorentz transformations, Minkowski space, tensor algebra. Relativistic particle dynamics, collision theory. Relativistic field theory, hydrodynamics, Maxwell field, electro-dynamics of material bodies, Klein-Gordon field. General theory: principle of equivalence, general covariance, tensor analysis. Einstein equations, Schwarzschild solution, geodesics, gravitational collapse, black holes. Geometrodynamics, superspace, quantization of Einstein equations. Cosmology: cosmological principle, Mach's principle, Robertson-Walker metric, mix master universe.

J. Van Kranendonk

2548. CELLULAR BIOPHYSICS

IV – 5p – – 2 –

The emphasis will be on the application of principles from physics, chemistry and genetics to quantitative studies in cell biology. Selected areas in biophysics such as cellular differentiation, the regulation of macromolecular biosynthesis, and the application of biophysical methods to problems in medicine, will be discussed in detail. Text: *Molecular Biology of the Gene* – Watson.

R. A. Phillips

2550. PHYSICS SEMINAR

IV – 5nt 2 – – –

The students will devise and carry out a seminar course on subjects of interest to them under the direction of a group of staff members. The course will only be given if a substantial number of students are interested. This course is the same as 2542 except one term only.

2551. QUANTUM OPTICS

IV – 5p – – 2 –

Stimulated emission. Laser theory. Coherence. Nonlinear optics including harmonic generation, parametric processes, stimulated scattering and self-focussing. Texts: *Nonlinear Optics* – Bloembergen; *Lasers* – Lengyel.

A. D. May

2552. HIGH ENERGY PHYSICS

IV – 5p – – 2 –

Description of the elementary particles and their decay. Symmetries: charge independence (SU2), strangeness conservation, SU3 and quarks. Notions of scattering theory such as the S-Matrix, partial waves, unitarity, dispersion relations and Regge poles. Emphasis will be on the phenomenology. Text: *Elementary Particles* – Frazer.

R. K. Logan

2553. INTERACTION OF RADIATION WITH MATTER

IV – 5p 2 – – –

Polarization, diffraction and interference of electromagnetic waves. Holography.

Metal optics. Crystal optics. Dispersion. Width of spectral lines. Electro-optical and magneto-optical effects. Text: *Principles of Optics* – Born and Wolf.

B. P. Stoicheff

2554. MAGNETIC RESONANCE

IV – 5p --2-

Motion of free spins. Macroscopic aspects. Crystal fields and the effective spin Hamiltonian. Magnetic interactions in a rigid lattice. Thermal relaxation in liquids and gases. Thermal relaxation in solids. Electric quadrupole effects. Dynamic nuclear orientation. Techniques: NMR, EPR, molecular beams, optical pumping, etc. Texts: *Principles of Magnetic Resonance*, by Slichter. *Paramagnetic Resonance*, by Pake.

R. L. Armstrong

2555. MOLECULAR PHYSICS

IV – 5p 2---

Treatment of the spectra of molecules and molecular crystals based mainly on symmetry considerations. Theory of groups and group representations. Born-Oppenheimer approximation. Rotation and vibration of diatomic and polyatomic molecules. Selection rules. Crystallographic point groups. Rotational and vibrational excitons. Text: *Group Theory and Quantum Mechanics*, by Tinkham.

R. L. Armstrong

2556. SOLID STATE PHYSICS

IV – 5p --2-

Description of Crystal Structures. Diffraction of x-rays by crystals, classification of solids. Elastic constants of crystals. Lattice vibrations. Thermal properties of solids. Dielectric properties. Text: *Introduction to Solid State Physics*, by Kittel.

J. S. M. Harvey

2557. NUCLEAR AND PARTICLE PHYSICS

IV – 5p 2---

Important discoveries in nuclear and particle physics. Radioactivity and gross nuclear properties. Nucleons, nuclear forces and nuclear structure. Fission and the physical basis of nuclear power. Unstable particles: hadrons, hypernuclei and leptons. Tools of nuclear and high energy physics: accelerators, modern nuclear detectors. Some current research with these tools. Text: *Atomic and Nuclear Physics*, by Shankland.

D. B. McConnell

2558. STATISTICAL MECHANICS

IV – 5p 2---

Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics with applications. Elementary theory of irreversible phenomena. Text: *Fundamentals of Statistical and Thermal Physics* – Reif.

J. Van Kranendonk

2559. MOLECULAR BIOPHYSICS

IV – 5p 2---

The physical and chemical properties of some biologically important macromolecules in relation to their functions. Techniques such as sedimentation, chromatography, spectroscopy, scattering of photons and electrons. The course is designed to give students with a physics and chemistry background an insight into the application of the exact sciences to the solution of biological problems. Text: *Molecular Biology of the Gene*, by Watson.

P. F. Ottensmeyer

2560. CLASSICAL PHYSICS OF CONTINUA

IV – 5g 2 – 2 –

Analysis of deformation of continuous medium. Stress tensor. Constitutive equations. Viscosity. Viscoelasticity. Wave motion in continuous media. Viscous hydrodynamics. Stability theory. Introduction to theories of turbulence. Text: *Introduction to the Mechanics of Continua* – Prager.

R. E. Wiggins

2561. THEORY AND APPLICATION OF GEOPHYSICAL METHODS

IV – 5g 2 – 2 –

A course on the mathematical theory of seismic, magnetic electrical and gravitational methods in pure and applied geophysics. Text: *Interpretation Theory in Applied Geophysics*, by Grant and West.

F. S. Grant

2568. GEOPHYSICS

IV – 9 2 – 2 –

An introduction to the physical principles underlying the important methods of geophysical prospecting. Particular attention is given to seismic, gravitational, magnetic and electromagnetic methods. Text: *Introduction to Geophysical Prospecting*, by Dobrin.

G. F. West

2569. GEOPHYSICS

IV – 9 – 3 – 3

A laboratory course in geophysical prospecting methods.

G. F. West

2570. PHYSICS OF THE EARTH

IV – 5g 2 – 2 –

Radioactivity and age of rocks, tectonics, glaciology, seismology and internal constitution of the Earth, gravity and the figure of the Earth, temperature and thermal history, geomagnetism and physics of the upper atmosphere, mechanical properties of the Earth's interior.

G. D. Garland

2571. ATMOSPHERIC PHYSICS

IV – 5g 2 – 2 –

Meteorological measurements, radiation, atmospheric statics and conditions for equilibrium, atmospheric thermodynamics, equations of motion, synoptic charts, the general circulations, condensations, condensation physics, atmospheric electricity.

Wind structure near the ground evaporation, the stratosphere. Text: *Dynamic and Physical Meteorology*, by Haltiner and Martin.

A. W. Brewer

2573. GEOPHYSICS LABORATORY

IV – 5g –9–9

A laboratory course stressing experimental and mathematical techniques applicable to the geophysical sciences.

R. M. Farquhar

DEPARTMENT OF CHEMISTRY

2631. ATOMIC AND MOLECULAR STRUCTURE

III – 5c 2–2–

The application of wave mechanics to some problems of atomic and molecular structure.

J. P. Valleau

DEPARTMENT OF POLITICAL ECONOMY

2720. ECONOMICS

II – All courses 2 – 2 –

An introduction to the study of Economics with special reference to the problems of the Canadian economy. Those students who obtain a satisfactory term mark will not be required to write the final examination. This course has equivalent value to Economics 100 as a pre-requisite for advanced courses in Economics.

J. P. Warner

2734. ACCOUNTING

III – 4 2 – 2 –

Basic accounting principles and procedures, the preparation and interpretation of financial statements, cost accounting, and the use of accounting as a means of control.

DEPARTMENT OF GEOLOGY

2900. GEOLOGY FOR ENGINEERS

II – 1 – – 2 2

An introductory course in geology with special reference to engineering problems.

2901. X-RAY CRYSTALLOGRAPHY

III – 5m, 8 – 2 – 2

A laboratory course in X-ray diffraction methods for students in Metallurgy and Material Science.

E. W. Nuffield

2920. PRINCIPLES OF GEOLOGY

II – 9 2 3 2 3
III – 5g 2 2 2 2

Basic concepts of physical and historical geology.

J. B. Currie, G. Norris

2921. MINERALOGY

II – 9 2 4 2 4

Introductory crystallography; the principle of mineralogy; classification and description of the common minerals; optical theory; the use of the polarizing microscope in the study of minerals; introduction to the study of rocks.

D. H. Gorman, J. C. Rucklidge

2922. GEOLOGICAL DATA PROCESSING BY COMPUTER

II – 9 1 2 1 2

Applied mathematics, probability, and statistics for processing geological data using computer methods.

F. G. Smith

2930. PETROLOGY

II – 9 2 2 2 2

The principles of petrology; the classification, description and interpretation of the sedimentary, igneous and metamorphic rocks. Microscopic petrography. One laboratory report.

J. J. Fawcett

2931. STRATIGRAPHY AND SEDIMENTATION

III – 9 2 2 2 2

Principles of stratigraphy with emphasis on tectonic and environmental interpretation of Precambrian and younger rocks. Problems of applied stratigraphy; petrographic interpretation.

F. W. Beales, A. M. Goodwin

2932. TECTONICS

III – 9 1 3 1 3

Geometry of existing deformational structures in the earth's crust, and reconstruction of their mechanical development.

W. M. Schwerdtner

2934. MINERAL IDENTIFICATION LABORATORY

III – 9 – 2 – 2

A continuation of the laboratory work in mineralogy of course 2921.

D. H. Gorman

2935. PHYSICAL GEOCHEMISTRY

III – 9 **3 – 3 –**

Chemical thermodynamics, phase diagrams, electrochemistry, states of matter, kinetics with examples from natural and experimental mineral systems at a wide range of temperatures and pressures.

G. M. Anderson, S. D. Scott, F. G. Smith

2937. GEOLOGICAL FIELD TRIPS

III – 9

Field trips to places of geological interest during the fall to complement the subjects studied in the III Year.

The Staff in Geology

2940. MINERAL DEPOSITS

IV – 9 **2 3 2 3**

Systematic mineralogy and phase equilibria of ore minerals. Identification of ore minerals in polished section. Geochemistry of ore-forming processes. Description of important ore deposits and discussion of their genesis.

A. J. Naldrett

2941S. PETROLEUM AND GROUND WATER GEOLOGY

IV – 9 **2 3 2 3**

Occurrence of oil and gas in sedimentary basins and the geological conditions that govern their entrapment; ground water and its relation to the geology of drainage basins; fluid flow through porous media.

J. B. Currie, W. D. Baines

2943. EXPLORATION GEOCHEMISTRY

IV – 9 **1 3 1 3**

Use of trace element analysis techniques as an aid to discovery of ore deposits.

G. M. Anderson

2944. MINERAL EXPLORATION

IV – 9 **2 – 1 3**

Case histories in mineral exploration, development and exploitation.

Staff in Geology

2946. GEOLOGY FIELD CAMP

IV – 9 **14 days**

A field course in the Tweed area of Ontario immediately following the Annual Examinations between the Third and Fourth Years.

The Staff in Geology

2947. GEOLOGICAL FIELD TRIPS

IV – 9

Field trips to places of geological interest to complement the subjects studied in the IV Year.

The Staff in Geology

DEPARTMENT OF COMPUTER SCIENCE

3310s. INTRODUCTION TO COMPUTER PROGRAMMING

I – 5 – – 1 1

Introduction to algorithms and stored-programme computers; FORTRAN programming; applications to numerical and non-numerical problems; simulations.

The Staff in Computer Science

3320. COMPUTER LANGUAGES

II – 5 – – 2 –

Definition of various programming languages including procedure oriented, list processing and simulation languages. Specification of syntax and semantics. Basic properties of programming languages.

3338s. PROGRAMMING AND DATA STRUCTURES

III – 5cs – – 3 6

Assembly Language Programming. Data structures with examples. Assemblers and macro-assemblers. Simple grammars and their recognition and translation.

3339. SYSTEMS PROGRAMMING AND PROGRAMMING LANGUAGES

IV – 5cs (commencing 1971–72)

Higher level languages, with examples of programming, recognition, and translation. Translator writing systems. Operating system principles, with emphasis on system architecture and design, and system services. Sorting and other commercial applications.

3341s. COMPUTER ORGANIZATION

III – 5cs; IV – 5cs 2 2 – –

Computer Structure, machine language, instruction execution, addressing techniques, and digital representation of data. Computer system organization, hierarchy of memory storage devices, logic design, microprogramming and emulators. Symbolic and assembly systems, macro definition and generation, program segmentation and linkage. Some case studies of actual machines to illustrate various architectures. This course is for the session 1970–71 only. It will be replaced in 1971–72 by Systems Programming and Programming Languages 3339.

3342s. THEORY OF COMPUTABILITY

IV – 5cs 2 – – –

Propositional calculus, predicate calculus, formal systems, primitive-recursive functions. Godel numbering and theorems, recursive functions, recursive sets. Turing machines, unsolvable problems, universal Turing machines, hierarchies of functions, computational complexity.

3343s. AUTOMATA THEORY

IV – 5cs — — 2 –

Finite automata, sequential machines, regular sets, regular expressions, generative grammars, context-free grammars and push-down automata, context-sensitive grammars and linear-bounded automata, operations on languages, bounds for recognition, decision problems, unified theory of automata.

3344s. OPERATING SYSTEMS

IV – 5cs — — 2 –

Process control, multiprogramming, generalized addressing, multiprocessing, parallel computations. Protection schemes. Resource allocation, static and dynamic scheduling. Dynamic storage allocation, paging. Memory management, page traffic. Reliability: debugging tools, error tolerance.

SPECIAL LECTURERS

3440. ENGINEERING LAW

IV – 3, 4 1 — — —

A subject designed to co-ordinate the practice of engineering and law. Consideration is given to the characteristics, advantages and disadvantages of companies, partnerships and sole proprietorships, the promotion, organization and financing of companies, the duties of employees to employers, the duties and liabilities of engineers, statutes applicable to engineering works, professional engineering associations, construction contracts, workmen's compensation, trade unions and industrial disputes. Textbook: *Engineering Law* – Laidlaw, Young, and Dick.

W. O. Chris. Miller

SCHOOL OF ARCHITECTURE

3540s. URBAN AND REGIONAL PLANNING

III – 1 (elective); IV – 1 (elective) — — 3 2

Spatial distribution of land use related to physical, ecological and transportation factors. Economic alternatives for the selection of industrial, residential and recreational location. Land use planning concerning natural resources, resource potential and conservation. Legal aspects of planning. Mathematical modelling and optimization of land use. (To be offered jointly by the Departments of Urban and Regional Planning and Civil Engineering.)

VII

General Regulations; Examinations

ATTENDANCE

1. Students proceeding to the degree are required to attend the courses of instruction and the examinations in all subjects prescribed. A student whose attendance at lectures or laboratories, or whose work, is deemed by the Council of the Faculty to be unsatisfactory may have his registration cancelled at any time.

2. Students must conform to all lecture room and laboratory regulations. Reports, briefs, theses and drawings become the property of the Council to dispose of as it may see fit. Drawings, briefs and field notes will not be accepted unless they have been made at the time and place provided in the time table.

PENALTIES FOR UNSATISFACTORY WORK

(*a*) In the case of unsatisfactory work of a very serious nature, the Faculty Council may recommend to the Senate that a student be debarred from the University.

(*b*) A student who on two occasions has failed to obtain promotion to a higher year will be refused further registration in the Faculty. A failure in engineering or in a related course at another institution will be counted in the same way as a failure in this Faculty.

(*c*) A student whose work is unsatisfactory may be suspended from attendance by the Council of the Faculty for a period of time not exceeding two years and/or until the satisfaction of other conditions as it may see fit.

(*d*) A student who withdraws after February 15, or who does not withdraw but does not write the annual examinations, will be regarded for the purposes of these regulations as having failed his year.

APPEALS

A student wishing to appeal to the Senate against a decision of the Council of the Faculty should consult the Secretary of the Faculty or the office of the University Registrar about the preparation and submission of his petition to the Secretary of the Senate.

ANNUAL EXAMINATIONS

1. Annual examinations will be held in April except as provided in paragraph 2 below.

2. Annual examinations will be held at the end of the first term in subjects completed during the first term.

3. Promotion from one year to another is made on the basis of the student's weighted average in the annual examinations and laboratory and other term work. In the calculation of the student's average the results of each course carry the weight indicated in the tables of curriculum. (See Section VI.)

Pass standing and promotion to the next higher year will be granted to students who obtain a weighted average of 60% or greater in the work of the year. (For special requirements in the first year of Engineering Science, see page 37.)

4. The student's work is graded in the following manner:

On Individual Courses

Marks	Grade
80 – 100%	1
70 – 79%	2
60 – 69%	3
50 – 59%	4
Below 50%	5

5. Honour standing will be granted to students who obtain a weighted average of 75% or greater in the work of the year.

6. Honour graduate standing will be granted to students who obtain honours in the final year and in any one previous year.

7. The following regulations pertain to failure and repetition of a year:

(*a*) A student who fails may be permitted to repeat the work of a year, subject to the conditions set out in the following paragraphs of this section.

(*b*) Only one such repetition will be allowed in the student's entire undergraduate course. For the purpose of this regulation, a failure in engineering or in a related course at any other institution will be counted in the same way as a failure in this Faculty.

(*c*) A student repeating a year must take the full program of instruction.

(*d*) A student who fails in the Second, Third or Fourth Year may repeat the work of the year in the session immediately following, unless he has previously repeated a year or is for other reasons ineligible.

(*e*) A student who has been admitted to advanced standing and who fails in his first year of attendance must file an application for re-admission, following the procedure outlined in Section III, paragraph 6 of this calendar.

(*f*) A student who fails in the work of the First Year may apply for re-admission to the Faculty, subject to the conditions set out below. *Applications of students for* *re-admission to the First Year will be considered on their merits, in competition with all other applicants.*

(i) A student who fails in the work of the First Year but who has obtained an average of 50% or over may apply for re-admission in the session immediately following.

(ii) A student who fails in the work of the First Year with an average lower than 50% may not apply for re-admission until one full session has elapsed.

(iii) A student who withdraws on or before February 15 may apply for re-admission in the session immediately following.

(iv) A student who withdraws after February 15, or who does not withdraw but does not write the final examinations is considered to have failed, and may not apply for re-admission until one full session has elapsed.

(v) Application for re-admission is made to the Office of Admissions on the regular admission application form, as outlined in Section III, paragraph 6, of this calendar.

9. A student should submit to Council immediately after its occurrence, evidence of any illness or mishap which occurs during the session; any petition for leniency on account of such incidents may be refused consideration if received after the third day following the last day of examinations.

10. A student will not be allowed to write any examinations if he has not paid all fees and dues for which he is liable at that time.

TERM EXAMINATIONS

Term examinations may be held in any subject and at any time at the discretion of the instructor, or by the order of the Council, and the results of such examination may be incorporated with those of the annual examinations in the same subjects.

EXTRA-CURRICULAR ACTIVITIES AND ACADEMIC CREDIT

It is in general desirable for students to engage to a reasonable extent in extra-curricular activities in order that they may not become too narrowly professional in interests and outlook, but it will be obvious that no academic credit or consideration can be given for such activities. Some offices in student organizations require quite large amounts of time for the proper performance of the duties connected with them, and it is therefore strongly recommended that students, particularly those whose academic records are not high, consult a senior member of staff before allowing themselves to be nominated for such offices.

TRANSFER OF PROGRAM

An undergraduate student who wishes to transfer from one program to another within the Faculty must petition to the Faculty Council and obtain its approval. Petitions for transfer of program must be submitted not later than July 15.

VIII

Medals, Prizes, Scholarships and Bursaries

Through the generosity of friends of the University, governments and commercial organizations, encouragement has been given to undergraduate work in the various branches of engineering study by the establishment of the scholarships, prizes, bursaries and medals listed in the following pages.

ADMISSION SCHOLARSHIPS AND BURSARIES

Ontario Students:

Scholarships and bursaries available to students entering the First Year are listed on pages 133 and 134. For full details concerning these awards, applicants should consult the Calendar of Admission Awards, which is available at Secondary Schools or from the Office of Student Awards, Simcoe Hall, University of Toronto. Applications, which must be made through the Principal of the Secondary School, close on May 1 annually.

Non-Ontario Students:

All non-Ontario students should apply to the Office of Student Awards, Simcoe Hall, University of Toronto. A limited number of scholarships is reserved for students living outside the Province of Ontario, but as competition is keen such students must not count on receiving assistance but are advised rather to ensure that they have sufficient funds from their own government or from private sources to cover all probable expenses.

IN-COURSE SCHOLARSHIPS AND BURSARIES

Scholarships, prizes, bursaries and loans available to students in attendance in the Faculty are listed on pages 134 to 137. Where it is necessary to make application for an award it is so stated in the description and particulars are given as to how the application should be made. In all other cases the award is made on the recommendation of the Faculty Council and no application is necessary.

GENERAL TERMS AND CONDITIONS

In order to be eligible for a medal, prize, scholarship, bursary, fellowship or other award granted solely upon standing obtained at an annual or special examination or upon an essay, or term work, or other academic rating, a candidate must obtain honours at such annual or special examination or upon such essay, term work, or other academic rating unless the terms of the award specify that standing lower than honours may be accepted.

When an award or medal is granted upon standing obtained on part of the work of any academic year the candidate must obtain standing but need not obtain honours in the work of the academic year as a whole, provided he obtains honours in the part concerned, unless the terms of the award or medal specify otherwise.

No medal, prize, scholarship, bursary, fellowship or other award will be granted to a candidate who is conditioned in any subject at an annual examination unless the terms of the award or medal specify otherwise.

A candidate will not be permitted to receive more than one award in a session unless the statute establishing each of the awards concerned or the Calendar specifies otherwise. Only one of those marked by an asterisk may be held in any one year. A candidate who would, but for this provision, have received more than one award may have his name so published in the class lists.

A candidate who has spent two sessions in any year of an undergraduate course is not eligible to compete for any award at the annual examinations of that year.

Medals, after they have been suitably engraved, will be given without delay to the winners or forwarded to them by registered mail.

Awards granted to members of graduating classes other than awards for graduate study and research, will be paid in one instalment as soon as possible after the granting of the awards.

All other awards will be paid (i) if of the value of $100 or less, in one instalment on November 20 and (ii) if of the value of more than $100 in two equal instalments, the first on November 20 and the second on January 20, in the session following the granting of the awards. Payment will be made only if the candidate is in regular attendance in the Faculty and, if the Calendar so specifies, in the course in which the award is established or granted.

The Senate may, on the recommendation of the Faculty, permit a candidate to whom an award has been granted to postpone attendance upon lectures and laboratory classes for one year. Further postponement may be permitted on application.

NOTE – As the value of an endowed scholarship or prize is dependent on the actual income of the fund, it is possible that the value of certain scholarships and prizes at the time of payment may be greater or less than the amount stated in the calendar.

In those cases where the amount of the award is not payable from income earned on an endowed fund, payment will be dependent on the receipt of the amount of the annual award from the donor.

AVAILABLE TO STUDENTS ENTERING THE FIRST YEAR

(† *indicates that application is required*)

Alumni Association War Memorial Scholarships	†	$ 500	page 162

Alcan Scholarship	†	$ 500	page 138
J. P. Bickell Foundation Scholarships	†	$ 500	140
J. W. Billes Admission Scholarships	†		142
Children of War Dead Education Assistance	†		143
Dominion Magnesium Limited Bursary	†	$ 400	144
Engineering Alumni Admission Scholarships (7)	†	$1000	145
Grabill Admission Scholarship	†	$ 500	147
Hagarty Memorial Scholarship	†	$ 60	147
The Murray Calder Hendry Scholarship	†	$ 500	148
Roy Jarvis Henry Admission Scholarships (3)	†	$ 500	148
International Nickel Scholarship	†	$ 300 + Fees	149
The Leonard Foundation Scholarships	†		150
J. Edgar McAllister Foundation	†		151
John Wolfe McColl Awards	†		151
Lachlan Dales McKellar Admission Scholarships (2)	†	$ 500	152
O.H.A. War Memorial Scholarship	†	$ 200	155
Ontario Chapter American Society for Metals Bursaries	†	$ 150	139
Ontario Student Awards Program	†		144
A.P.E.O. Admission Scholarship	†	$ 500	156
Regular Officer Training Plan	†		158
Helen E. Rogers Admission Scholarships	†		158
Simpson-Sears Limited (Northern Ontario) Scholarship	†	$ 100	159
Walter Sterling Admission Scholarships	†		161
U.T.S. Engineering Scholarship	†	$ 250	162
Wallberg Admission Scholarships (2)	†	$ 500	163

AVAILABLE TO STUDENTS COMPLETING THE FIRST YEAR

(† *indicates that application is required*)

Baptie Scholarship		$ 175	140
Canadian Bechtel Limited Bursaries	†		140
J. P. Bickell Foundation Scholarships			140
T. H. Bickle Prize		$ 30	141
Crocker Foundation Bursaries	†		144
John M. Empey Scholarship		$ 170	145
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		149
Johnson's Wax Scholarship		$ 800	150
Kimberly-Clark Scholarship		$ 500	150
John Wolfe McColl Awards	†		151
Garnet W. McKee-Lachlan Gilchrist Scholarship in Engineering Science		$ 110	151
MacLennan – MacLeod Memorial Prize		$ 25	144

MacLennan – MacLeod Memorial Prize		$ 25	page 153
*Marsland Engineering Ltd. Scholarship		$ 250	153
Ontario Student Awards Program	†		144
Orenda Limited Scholarship		$ 500	155
Paulin Memorial Scholarship		$ 475	155
Procter and Gamble Bursary	†		155
*Professional Engineers Scholarship		$ 250	156
Ransom Scholarship in Chemical Engineering		$ 250	156
Frederick W. Schumacher Scholarship	†		159
S. Ubukata Fund	†		162
*Wallberg Undergraduate Scholarships (2)		$ 500	163

AVAILABLE TO STUDENTS COMPLETING THE SECOND YEAR

(† *indicates that application is required*)

Harvey Aggett Memorial Scholarship		$ 75	138
Ardagh Scholarship		$ 350	139
Automotive Transport Association Bursary	†		139
Babb Bursary Fund	†		140
Canadian Bechtel Limited Bursaries	†		140
J. P. Bickell Foundation Bursaries	†		141
J. P. Bickell Foundation Scholarships			140
T. H. Bickle Prize		$ 30	141
Carveth Metallurgical Ltd. Bursary	†	$ 500	142
Crocker Foundation Bursaries	†		144
Cyanamid of Canada Scholarship		$ 900	144
John M. Empey Scholarship		$ 170	145
J. A. Findlay Scholarship		$ 80	146
Hugh Gall Award	†	$ 140	147
Hydro-Electric Power Commission of Ontario Bursary	†	$ 500	149
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		149
Kimberly-Clark Scholarship		$ 500	150
Scholarships			151
Charles Gordon Manning Prize			153
*Marsland Engineering Ltd. Scholarship		$ 250	153
James L. Morris Memorial Prize		$ 125	154
Ontario Student Awards Program	†		144
Orenda Limited Scholarship		$ 500	155
*Spruce Falls Power and Paper Company Scholarships		$ 400	160
William Storrie Memorial Scholarship		$ 100	161
*Professional Engineers Scholarship		$ 250	156
*Rhodes Scholarship	†	£1000	156
Frederick W. Schumacher Scholarship	†		159

Edith Tyrrell Memorial Bursary	†	$ 600	page 161
Wallberg Undergraduate Scholarships		$ 500	163
William R. Worthington Memorial Scholarship		$ 400	163

AVAILABLE TO STUDENTS COMPLETING THE THIRD YEAR

(† *indicates that application is required*)

American Institute of Industrial Engineers Scholarship		$ 150	139
Babb Bursary Fund	†		140
F. W. Baldwin Prize		$ 75	140
Canadian Bechtel Limited Bursaries	†		140
J. P. Bickell Foundation Bursaries	†		141
T. H. Bickle Prize		$ 30	141
*Boiler Inspection and Insurance Company Scholarship		$ 300	142
*Chevron Standard Limited Scholarship		$ 500	142
Chemical Institute of Canada Prize		$ 25	143
5T6 Civils Scholarship	†	$ 200	143
Cominco Scholarships	†	$ 800	143
Crocker Foundation Bursaries	†		144
Dow Chemical of Canada Limited Award		$ 500	144
John M. Empey Scholarship		$ 170	145
E.I.C. Prize		$ 50	146
Engineering Society Semi-Centennial Award		$ 75	146
J. A. Findlay Scholarship		$ 80	146
James Franceschini Foundation Scholarship		$ 300	146
Chester B. Hamilton Scholarship		$ 500	148
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		149
*Jenkins Scholarship in Engineering		$ 200	149
Loan Funds	†		164
J. A. D. McCurdy Prize		$ 75	151
Alexander MacLean Scholarship		$ 250	152
*Marsland Engineering Ltd. Scholarship		$ 250	153
Ontario Student Awards Program	†		144
Orenda Limited Scholarship		$ 500	155
*Professional Engineers Scholarship		$ 250	156
RCE Memorial Scholarship	†	$ 125	158
Don Salt Memorial Scholarships	†	$ 500	158
Murray F. Southcote Scholarship		$ 100	160
Frederick W. Schumacher Scholarship	†		159
William Storrie Memorial Scholarship		$ 100	161
*Spruce Falls Power and Paper Company Scholarships		$ 400	160
Edith Tyrrell Memorial Bursary	†	$ 600	161
Wallberg Undergraduate Scholarships		$ 500	163

AVAILABLE TO STUDENTS COMPLETING THE FOURTH YEAR

(† *indicates that application is required*)

Henry G. Acres Medal			page 138
American Society of Lubrication Engineers Prize		$ 75	139
J. P. Bickell Foundation Bursaries	†		140
Babb Bursary Fund			140
Crocker Foundation Bursaries	†		144
Electrical Manufacturing Co. Limited Prize		$ 25	145
Hamilton Watch Award			148
Loan Funds	†		164
Massey-Ferguson Ltd. Scholarships (2)	†	$ 500	154
Ontario Student Awards Program	†		144
Otto Holden Scholarship		$ 750	154
Professional Engineers Gold Medal			156
J. E. Reid Memorial Prize		$ 50	157
William Storrie Memorial Scholarship		$ 200	161
Wallace Award, Society of Automotive Engineers Prize		$ 100	160
Society of Chemical Industry Merit Award			160
"Second Mile Engineer" Award		$ 200	159
W. S. Wilson Medals			163

HENRY G. ACRES MEDAL

The Henry G. Acres Medal is the gift of Mrs. Henry G. Acres in memory of her late husband, Henry G. Acres, M.E., D.Sc., a graduate of the School of Practical Science in the class of 1903. Throughout his professional life Dr. Acres was associated with major power developments in Canada and abroad. As chief hydraulic engineer for the Hydro-Electric Power Commission of Ontario in the period 1911 to 1923, he was responsible for the design and construction of nearly twenty power plants, including the Queenston-Chippewa development. Entering private practice in 1924, and until his death in 1945, he continued to widen and extend his interests. He became chief engineer of the Grand River Conservation Commission and responsible for the design and construction of the Shand dam and related work. Later, he was consulting engineer for the extensive power developments at Shipshaw on the Saguenay River, which was vital to the production of aluminum for war purposes. Many of the provinces of Canada sought his services and he advised with respect to work in Newfoundland, South America and India.

This medal is awarded annually to the student in the Fourth Year who is registered in the course in Civil, Mechanical, or Electrical Engineering, and who obtains the highest aggregate percentage at the annual examinations of the Third and Fourth Years, provided always that the student obtains honour standing in the examinations of the Fourth Year. Receipt of the medal does not preclude a student from being granted such other award as may in the opinion of the Council be appropriate.

HARVEY AGGETT MEMORIAL SCHOLARSHIP

This scholarship was donated by the late Mr. J. T. Aggett, of Toronto, as a perpetual memorial to his son, the late Lieutenant Harvey Aggett, who enlisted in March, 1915, during his second year in this Faculty, and was killed in action at Passchendaele on November 6, 1917.

This annual scholarship of the value of the annual income from the fund is to be awarded to a student of the Second Year in this Faculty who, obtaining honours and being one of the first three in his year by his standing at the annual examinations, has been adjudged highest of the three in general student activities and service in the University during his period of attendance. When regulations do not permit the winner to hold this scholarship the students to be considered for the award shall be the first three in the year exclusive of any student who holds a scholarship of higher value.

ALCAN SCHOLARSHIP

The Aluminum Company of Canada, Limited, has made available an admission scholarship of a value of $500 to a student entering the First Year of an Honours Course in the Faculty of Arts and Science, the Faculty of Applied Science and Engineering or in the Faculty of Law. The recipient must attain an academic standing satisfactory to the Committee of Award and demonstrate financial need. It is tenable in the later years provided First Class standing is maintained. As the award is tenable for a possible four years and only one shall be outstanding in any year, the next Alcan Scholarship will become available in the session 1973–74.

Application should be made to the Office of Student Awards by May 1 on the regular Admission Scholarship Application form.

AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS SCHOLARSHIP

The Southern Ontario Chapter, American Institute of Industrial Engineers offers a scholarship of $150 to a student entering the Fourth Year of the Industrial Engineering course who has consistently maintained a high academic standing, but not necessarily honour standing, during the previous three years.

AMERICAN SOCIETY OF LUBRICATION ENGINEERS PRIZE

The Toronto section of the American Society of Lubrication Engineers offers an annual prize of $75 to a student in the Fourth Year in Mechanical Engineering whose Thesis dealing with Lubrication is considered by the Head of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory. The Prize is accompanied by a donation of $25 to the Department to purchase books on Lubrication.

ONTARIO CHAPTER, AMERICAN SOCIETY FOR METALS BURSARY

The Ontario Chapter, American Society for Metals provides several bursaries of a value of $150 each for students entering the First Year in Metallurgy and Materials Science. The award is made primarily on Grade XIII standing but the need for financial assistance is also taken into consideration.

Application should be made by letter to the Secretary not later than September 1. The first award was made for the Session 1958–59.

ARDAGH SCHOLARSHIP

The Ardagh Scholarship, of the annual value of the income from $7,500, has been provided in memory of his parents by Professor E. G. R. Ardagh, B.A.Sc., F.R.S.C., formerly professor of Applied Chemistry in the Faculty. It is awarded to the student who attains the highest standing in all Honours at the annual examination of the Second Year in the Course in Chemical Engineering. The first award was made on the results of the annual examination of 1946.

ATA TRUCKING INDUSTRY EDUCATIONAL FOUNDATION BURSARIES

The Automotive Transport Association of Ontario has established a bursary fund for students in the second or higher years of any undergraduate degree course who find themselves in serious financial need due to sudden, unexpected personal or family difficulties. Applications may be submitted to the University Registrar at any time during the session and the number and value of the bursaries will vary at the discretion of the Committee of Award.

THE BABB BURSARY FUND

Bursaries from this fund are available to students in any year of the Aeronautics Option in Engineering Science. Application is made through the Secretary of the Faculty.

THE F. W. BALDWIN PRIZE

The F. W. Baldwin Prize of a value of $75 was established by the trustees of a fund created by the members of the Number 3 Squadron, University Air Training Corps (1941–44), in memory of Frederick Walker "Casey" Baldwin, a graduate of the School of Practical Science, who made a significant contribution in the field of Aeronautics in Canada; and who flew, on March 12, 1908, near Hammondsport, N.Y., the "Redwing," the first biplane built by the Aerial Experiment Association.

It is awarded annually to the student registered in Third Year, Aeronautics Option, in Engineering Science, who, taking honours, ranks highest in the annual examinations of Third Year in "structural subjects."

The first award was made on the results of the examinations of the Session 1953–54.

BAPTIE SCHOLARSHIP

The Baptie Scholarship is derived from a bequest under the will of the late Mrs. Margaret W. Baptie, of Ottawa, and the Board of Governors has directed that a scholarship of one half the annual income shall be awarded annually to an engineering student on the record of the first Year. The Board of Governors also authorizes a remission of fees in the case of the holder of the scholarship, up to $75.

The conditions of the award are as follows: That the scholarship be awarded to the student who, in the annual examinations of the First Year, enrolled in any one of the courses of Civil Engineering, Mechanical Engineering, Chemical Engineering, Electrical Engineering, or Metallurgy and Materials Science, obtains the highest aggregate percentage of marks in those subjects which are common to the First Year curricula of those courses. The first award was made on the results of the annual examinations of the Session 1925–26.

CANADIAN BECHTEL LIMITED BURSARIES

Canadian Bechtel Limited has established Bursaries in the Faculty of Applied Science and Engineering of an annual value of $1,200 to provide not more than four awards, each of a minimum value of $200 and a maximum value of $600. Two awards will be made to First Year students and one or two awards to students registered in any year of the Faculty. Applicants must demonstrate financial need and have academic standing satisfactory to the Faculty Council.

Application must be made to the Secretary of the Faculty on or before October 1.

J. P. BICKELL FOUNDATION SCHOLARSHIPS

The Trustees of the J. P. Bickell Foundation have established scholarships, the number to be determined annually, in the Faculty of Applied Science and Engineering of a possible value of $1,500 payable $500 in the First Year and provided honours are obtained at the Annual Examinations, $500 in the Second and Third Years.

An applicant must obtain an average of at least 75% at the Ontario Grade XIII examinations immediately preceding his admission to the university and must undertake to enrol in Chemical Engineering, Metallurgy and Materials Science or Geological Engineering. Failing suitable candidates in the courses mentioned students registered in the Second Year Honour course in Geological Sciences, or Physics and Geology in the Faculty of Arts and Science who are academically qualified are eligible. These awards are of the same value and are tenable in the Second, Third and Fourth Years of the course, subject to maintenance of the required academic standing. If any scholarships are not awarded to those mentioned above, students registered in the Third Year of the Engineering Science course in the Faculty of Applied Science and Engineering and taking the Physical Metallurgy or the Geophysics option who are academically qualified are eligible. In this case the scholarship will have a value of $1,000, payable $500 in each of the Third and Fourth years, provided the required academic standing is maintained.

Applications from those entering First Year must be submitted to the Office of Student Awards not later than May 1 on the regular admission scholarship application form. In other cases, applications are not required.

J. P. BICKELL FOUNDATION BURSARIES

The Trustees of the J. P. Bickell Foundation have established the J. P. Bickell Foundation Bursaries in the Faculty of Arts and the Faculty of Applied Science and Engineering. An applicant must be enrolled in Honour Science or in Mathematics, Physics and Chemistry in the Faculty of Arts, in which case he must undertake to study mining or geology in his higher years; or be enrolled in a higher year of an honour course in the geological or geophysical field in the Faculty of Arts; or be enrolled in Chemical Engineering, Mining Engineering, Metallurgy and Materials Science, or Geological Engineering in any year of the Faculty of Applied Science and Engineering. He must demonstrate financial need and have satisfactory academic standing.

Application must be made to the Office of Student Awards on or before October 15.

THE T. H. BICKLE PRIZE

The T. H. Bickle Prize is the gift of Mr. and Mrs. E. W. Bickle in memory of their son, T. H. Bickle, an undergraduate of Trinity College and a member of the Senior Intercollegiate Swimming Team at the time of his death in 1937. The income from the endowment fund will be used to purchase a suitable prize to be awarded annually to a member of the Senior Intercollegiate Swimming Team of this University in any year, faculty or school. The Committee of Award shall consist of the Dean of the

Faculty of Arts, the University Registrar, the Director of Athletics, and the Honorary Coach of Swimming. In awarding the Prize the Committee shall consider the character, scholarship, and general interests of the members of the team.

J. W. BILLES ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of J. W. Billes, open to students entering any degree course in the University. The value in each year is a minimum of $250 and a maximum of $1,500 dependent upon the financial need of the recipient. Applicants must satisfy the normal admission scholarship standards in their Grade XIII examinations to be eligible for an award and maintain first class honour standing to enjoy the scholarship in higher years. The number of scholarships awarded in any one year may be varied dependent upon the available funds.

Application should be made to the Office of Student Awards by May 1 on the regular admission scholarship application form.

BOILER INSPECTION AND INSURANCE COMPANY SCHOLARSHIP

The Boiler Inspection and Insurance Company of Canada offers a scholarship in the Course in Mechanical Engineering of the value of $300 to the student who obtains highest honour standing in the regular examinations of the Third Year.

The successful candidate will be expected to proceed to his Fourth Year during the session next following the date of the award.

The amount of the award will be credited by the Chief Accountant to the fees of the Fourth Year of the successful candidate.

CHEVRON STANDARD LIMITED SCHOLARSHIP

Chevron Standard Limited has presented a scholarship of $500 to a student who achieves outstanding results in the annual examinations of the Third Year in the Geophysics Option in Engineering Science or in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and Science.

The awards alternate annually between the Faculties of Applied Science and Engineering and Arts and Science and the First Award was made in the session 1960–61 in the Faculty of Applied Science and Engineering.

CARVETH METALLURGICAL LTD. BURSARY

Carveth Metallurgical Ltd. provides one or more bursaries to a total value of $500 for students entering the Third Year of Metallurgy and Materials Science. The award is made primarily on the basis of Second Year standing, but the need for financial assistance will also be taken into consideration.

The Bursary is available every third year, beginning in the Session 1961–62, and is to be awarded on the recommendation of the Department of Metallurgy and Materials Science. Applications should be made by letter to the Secretary of the Faculty of Applied Science not later than September 1 of the year in which the award is tenable.

CHEMICAL INSTITUTE OF CANADA PRIZE

The Chemical Institute of Canada offers a prize of the annual value of $25 in books to the student registered in the course in Chemical Engineering who, having obtained honours, receives the highest standing in the written and laboratory work of the Third Year.

The first award was made on the results of the final examinations of 1947.

CHILDREN OF WAR DEAD (EDUCATION ASSISTANCE) ACT

Children of War Dead (Education Assistance) Act provides fees and monthly allowances for children of veterans whose death was attributable to military service. Enquiries should be directed to the nearest District Office of the Department of Veterans Affairs.

5T6 CIVILS SCHOLARSHIPS

The 5T6 Civils, consisting of the graduating members of the 1956 Civil Engineering Class of the University of Toronto, have established an annual scholarship of the value of $200.00 open to students who have completed the Second Year of the course in Civil Engineering and are registered in the Third Year of the course. The selection of the recipient is based on evidence of the qualities of scholarship, leadership and character. The award is not tenable with any other scholarship of greater value.

The award is presented at the annual reunion of the Class of 5T6 Civils. The first award was made in 1964.

Students who wish to be considered for this scholarship should write to the Class of 5T6 Civil Engineering, c/o Alumni House, University of Toronto, not later than December 31, giving full particulars of their academic record, and their extra-curricular activities both within and outside the University.

COMINCO SCHOLARSHIPS

Two scholarships, of an annual value of $800 each, are provided by Cominco Limited and are offered to students in the Third Year of the courses in Chemical Engineering, Geological Engineering, Mechanical Engineering and Metallurgy and Materials Science in the Faculty of Applied Science and Engineering and to students in the Third Year of the courses in Chemistry and Geology in the Faculty of Arts and Science, the awards being made on the basis of the examination results of the Seecond Year. The scholarships may be renewed in the Fourth Year if satisfactory standing is maintained.

Application must be made to the Secretary of the Faculty on the regular in-course awards form not later than October 15.

CROCKER FOUNDATION BURSARIES

The income from a capital fund established from the estate of the late Beatrice Crocker Glazier in memory of her brother, James William Crocker, provides bursaries for students in the Faculty of Medicine and the Faculty of Applied Science and Engineering who are in need and are worthy of financial assistance.

Application should be made to the Secretary of the Faculty not later than October 15.

CYANAMID OF CANADA SCHOLARSHIP

As a part of their programme to encourage technical development in Canada, Cyanamid of Canada Limited offers a scholarship of the value of $900 to a student entering the Third Year in Chemical Engineering or Industrial Engineering. The award is made to a student who has demonstrated high academic ability and outstanding scholarship in the work of the Second Year.

The first award at the University of Toronto was made in 1964.

DOMINION MAGNESIUM LIMITED BURSARY

Dominion Magnesium Limited provides a bursary of $400 for a student entering the First Year in Metallurgy and Materials Science. The award is made primarily on Grade XIII standing but the need for financial assistance is also taken into consideration.

Application should be made by letter to the Secretary not later than September 1. The first award was made in the Session 1958–59.

PROVINCE OF ONTARIO STUDENT AWARDS PROGRAM

The Ontario Student Awards Program is intended to provide opportunities for students of this province who lack adequate financial resources to pursue post-secondary education. To be eligible to apply for assistance the student must be a Canadian citizen or landed immigrant and must have resided in the Province of Ontario for at least twelve months prior to entering the university program for which he is seeking assistance.

The program is intended to supplement rather than replace family and/or student resources. In order to determine the additional funds required the province assesses the cost of the student's education and the resources of the family and/or the student which could reasonably be applied toward the educational costs. The difference between the costs and resources, if any, is provided to the student in a combination of a loan and a free grant in the following proportions: the first $150 is a loan; the next $750 or portion thereof is 60% loan, 40% grant; the balance, if any, beyond $900 is given as a grant.

Application forms and further information may be obtained from the Office of Student Awards, Simcoe Hall, University of Toronto, from May 1 onward. Application well in advance of the commencement of the academic session is advisable.

DOW CHEMICAL OF CANADA LIMITED AWARD

Dow Chemical of Canada Limited have provided funds for an annual award of $500 to a student in Chemical Engineering in the Faculty of Applied Science and Engineering, and grant-in-aid of $250 to be used in the winner's department to help defray the cost of equipment, supplies and administration.

The winner must:

(*a*) be registered in the Third Year in Chemical Engineering (the award will be made in the second term of the Third Year and will be paid to the winner during his Fourth Year);

(*b*) be in the upper half of the class;

(*c*) have demonstrated leadership in extra-curricular activities.

The award is not tenable with other awards in the gift of the Senate. Application is not required.

THE ELECTRICAL MANUFACTURING COMPANY LIMITED PRIZE

The Electrical Manufacturing Company Limited has established an annual Prize of $25 in the Faculty of Applied Science and Engineering.

The winner must:

(*a*) be registered in the Fourth Year in Electrical Engineering;

(*b*) obtain the highest aggregate percentage of marks at the final examinations in the subjects of the Fourth Year related to electrical distribution equipment, the subject to be determined by the Head of the Department of Electrical Engineering.

This Prize is tenable with other awards in the gift of the Senate.

THE JOHN M. EMPEY SCHOLARSHIPS

The John M. Empey Scholarship Fund was established under a bequest of $10,000 in the Will of the late John Morgan Empey, B.A.SC., 1903. Three scholarships of equal value are provided from the income from the Fund. One of these scholarships is awarded in each of the First, Second, and Third Years on the results of the annual examinations, to a student who, taking honours, obtains the highest average percentage of marks in the written and laboratory subjects of his Year. The scholarships are open to any students registered in the Faculty. In case the winner of any one of these scholarships does not attend this Faculty during the session next following the award, the right to the scholarship shall be forfeited and the award shall be made to another eligible student. The scholarships were awarded for the first time in 1944.

ENGINEERING ALUMNI ADMISSION SCHOLARSHIP

Seven scholarships, each of the value of $1000, are provided annually by the University of Toronto Engineering Alumni Association for students entering the first year of any course in the Faculty of Applied Science and Engineering. The awards are made on the basis of standing in the Ontario Grade XIII examinations.

Application should be made to the Office of Student Awards by May 1 on the regular admission scholarship application form.

ENGINEERING INSTITUTE OF CANADA PRIZE

The Engineering Institute of Canada, having in view that one of its objects is to facilitate the acquirement and interchange of professional knowledge among its members, offers an annual prize of Fifty Dollars in this University, commencing 1931, to the student who, in his Third Year in any one of the six courses of Engineering, has proved himself most deserving as disclosed by the examination results of the year, in combination with his activities in the Engineering Society or with a local branch of another recognized engineering organization.

ENGINEERING SOCIETY SEMI-CENTENNIAL AWARD

The Engineering Society Semi-Centennial Award, to the value of $75 was established in 1931 to commemorate the semi-centennial of the founding of the "School." The award is made to a student entering the final year.

The selection is based upon the following qualifications, which bear equal weight in the selection of the winner: (*a*) General "School" activities. (*b*) Contributions to the Engineering Society Executive Committee. (*c*) Personality, and social and athletic activities. (*d*) Academic standing.

J. A. FINDLAY SCHOLARSHIPS

These scholarships were established through a legacy bequeathed by the late Miss Janet Findlay to the Department of Mechanical Engineering. Two scholarships are available, each of a value of one half of the income of the fund, to students in this Course, one for a student in the Third Year, the other for a student in the Fourth Year, but only if the student continues his course in Mechanical Engineering. The selection will be made, on recommendation of the Head of the Department of Mechanical Engineering, from amongst the four students having the highest average percentage of marks at the annual examinations in the Second and Third Years respectively, but in making the award the student's general character, fitness for his profession, and financial circumstances will be given consideration. In case a student who has been awarded one of the scholarships changes his course or does not attend this University during the next following session, he shall forfeit his right to the scholarship and the award shall be made to another eligible student.

THE JAMES FRANCESCHINI FOUNDATION SCHOLARSHIP

This scholarship, of a value of $300, is awarded to the student in Civil Engineering who achieves the highest standing, with honours, at the annual examinations of the Third Year among those who do not hold an award of a value of $100 or more based on the results of these examinations.

HUGH GALL AWARD

The Hugh Gall Award, of the annual value of One Hundred and Forty Dollars, the gift of the Graduate Class of 1910, "to commemorate a deceased classmate who was a splendid type of student, a loyal friend, and nationally outstanding in athletic achievement during his undergraduate career," was established in 1946 for a five year period and, through the generosity of Mrs. Hugh Gall extended for a further period. It is awarded to a student, who, having completed his First Year with a general average of at least 66% without conditions, has entered the Second Year, and is in special need of financial assistance in order to enable him to continue his course. It is desirable, but not necessary, that the recipient shall not already have been given any other scholastic award or scholarship applicable to the second year and he shall have shown indications of his firm intention and ability to follow successfully the profession of engineering.

Any second year student in the Faculty of Applied Science and Engineering is eligible to apply for this Bursary. Applications should be made to the Secretary of the Faculty not later than October 15.

THE GRABILL ADMISSION SCHOLARSHIP

The Grabill Admission Scholarship is the gift of Mr. Dayton L. Grabill, a graduate of this Faculty in 1924. The Scholarship has a value of approximately $500. It is awarded to the candidate who has standing amongst those with the highest average percentages in the subjects of Ontario Grade XIII required for admission to the Faculty of Applied Science and Engineering. The candidate must write the Grade XIII examinations at one sitting in the June preceding entry to the University after not more than one year's instruction in Grade XIII and must register in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards on the regular Admission Scholarship form by May 1.

THE REGINALD AND GALER HAGARTY SCHOLARSHIP

The Reginald and Galer Hagarty Scholarship, in memory of the dearly beloved sons of Lieutenant-Colonel E. W. Hagarty, B.A. 1883, M.A. 1908, and Charlotte Ellen Hagarty, his wife. Reginald Edward Walter Hagarty, B.A.SC. (Honours) 1908, a graduate of the University in the Faculty of Applied Science and Engineering and at the time of his death on April 29, 1925, a Consulting Structural Engineer. Lieutenant Daniel Galer Hagarty, Princess Patricia's Canadian Light Infantry, a member of the class of 1916 in Applied Science, enlisted for the Great War at the end of his third year in June, 1915, killed in action in Sanctuary Wood, June 2, 1916. The scholarship is given in recognition of the fact that their father was an honour graduate in Classics of the University of Toronto. It is of the value of the annual interest on the capital sum of $2,000 and is to be awarded to a student who has been enrolled for his Grade

XIII Year at Harbord Collegiate Institute and having obtained at least the required standing in each of the Grade XIII subjects necessary for admission to the Faculty, obtains the highest standing in English, a language other than English, and Mathematics, among the students who apply for the award from the Collegiate. He will be required to: (*a*) register in the Faculty of Applied Science and Engineering, (*b*) sign a declaration to the effect that he is willing to take up arms in the defence of Canada and the British Commonwealth should necessity arise as declared by the Parliament of Canada. The Scholarship was offered for award for the first time in 1945. Application should be made to the Office of Student Awards on the regular admission scholarship application form not later than May 1.

CHESTER B. HAMILTON SCHOLARSHIP

Members of the family of the late Chester B. Hamilton, a graduate of the Faculty in 1906, have presented a Scholarship in his memory of the annual value of $500. It is held by a Fourth Year student in Mechanical Engineering who has achieved outstanding academic standing at the Annual Examinations of the Third Year.

The first award was made on the results of the examinations for the Session 1958–59.

HAMILTON WATCH AWARD

Hamilton Watch Company, Lancaster, Pa., presents a wrist watch, suitably engraved, to the Fourth Year student in the Faculty of Applied Science and Engineering who at the annual examinations attains Honour standing and who has achieved high aggregate marks during his four years in the social-humanistic subjects common to all courses.

THE MURRAY CALDER HENRY SCHOLARSHIP

This award was established by the estate of Mrs. Grace Appel Hendry as a memorial to her husband, a graduate of this Faculty in 1905. It has a value of the income from a capital sum of $10,000 and the recipient must:

(*a*) have attained an average of at least 75% on the grade XIII examination papers, written at one sitting, required for admission to the Faculty.

(*b*) be entering the First Year of any course in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards by May 1 on the regular University Admission Scholarship Application form.

The first award was made in the Session 1962–63.

ROY JARVIS HENRY ADMISSION SCHOLARSHIPS

The estate of the late Roy Jarvis Henry provides three scholarships of the value of $500 each, to be awarded to students who have achieved high standing on the

Ontario Secondary School qualifications required for admission, two of which are open to students entering any course in the Faculty and one open to students entering Geological Engineering. In the lack of a suitable candidate in Geological Engineering, all three awards are tenable in any course in the Faculty. Application must be made on the regular admission scholarship application form.

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO BURSARY

The Hydro-Electric Power Commission of Ontario has provided a bursary of the value of $500, which may be awarded to a student entering the second year of the courses in Mathematics and Physics or Commerce and Finance in the Faculty of Arts and Science, or any course in the Faculty of Applied Science and Engineering. Application should be made on the regular in-course bursary form not later than October 15.

IBM – THOMAS J. WATSON MEMORIAL BURSARY FUND

International Business Machines Company Limited has made available one or more bursaries of a total annual value of $1,000 to students registered in any year of a full time course in the university who have standing satisfactory to the committee of Award and demonstrate financial need.

Application should be made to the Office of Student Awards by October 15.

INCO SCHOLARSHIPS

The International Nickel Company of Canada, Limited, annually provides one scholarship to students entering the University of Toronto for studies in Engineering, Geology, Geophysics, Mathematics, Physics or Chemistry with preference being given to Metallurgical Engineering. Awards are renewable for three additional academic years provided satisfactory standing is maintained.

Valued at $1,200 annually, each scholarship provides for tuition and fees, a $300 living allowance, and a grant of up to $500 to the University as a cost-of-education supplement.

To be eligible for consideration the applicant must obtain an average of 75% or over in the Ontario Grade XIII subjects required for admission to his course and demonstrate financial need.

Application must be made to the Office of Student Awards by May 1 on the regular scholarship application form.

JENKINS SCHOLARSHIP

The Jenkins Scholarship, presented by Jenkins Bros., Limited, Montreal, first awarded in 1925, has been donated to continue indefinitely.

This Annual Scholarship, of the value of $200, is awarded to the student of the Third Year registered in any course of the Faculty who has the highest aggregate of percentages for the First, Second and Third Years.

JOHNSON'S WAX SCHOLARSHIP

S. C. Johnson and Son Limited, Brantford, Ontario, have established a Scholarship of an annual value of $800 in each of the Second, Third and Fourth Years or a total possible value of $2,400.

The recipient must:

(*a*) be registered in Chemical Engineering in the years in which the Scholarship is awarded and held;

(*b*) in the opinion of the Council be the most promising and deserving member of the class, obtaining Honours in the final examinations of the First Year;

(*c*) in his Second and Third Years, maintain academic standing satisfactory to the Council, not necessarily Honours, for the continued enjoyment of the Scholarship. In its discretion the Council may recommend the award of any portion of the Scholarship, lost by the original recipient by failure to maintain satisfactory academic standing, to another student of the year(s) in which the Scholarship would otherwise have been enjoyed.

The first award was made on the results of the annual examinations written in April 1954. It is not tenable with any other Scholarship.

KIMBERLY-CLARK CORPORATION OF CANADA LIMITED SCHOLARSHIPS

Kimberly-Clark Corporation of Canada Limited has presented two scholarships of a value of $500 each and each scholarship is accompanied by a grant of $100 to the general funds of the University. One scholarship is awarded to an outstanding student of the First Year and one to an outstanding student of the Second Year as indicated by the examination results of their respective years. Students in all courses of the First and Second Years are eligible.

The first awards were made on the results of the annual examinations for 1957–58.

THE LEONARD FOUNDATION SCHOLARSHIPS

Leonard Foundation Scholarships are awarded each year to selected students in Universities and Colleges across Canada, including the University of Toronto. The Trust Deed states: "Preference in the selection of students for scholarships shall be given to the sons and daughters respectively of the following: (*a*) clergymen, (*b*) school teachers, (*c*) officers, non-commissioned officers and men, whether active or retired, who have served in Her Majesty's military, naval or air forces, (*d*) graduates of the Royal Military College of Canada, (*e*) members of the Engineering Institute of Canada, (*f*) members of the Mining and Metallurgical Institute of Canada."

All applicants must be nominated by a member of the General Committee. The latest date for the receiving of applications is March 31, for the following academic year. Further information regarding the procedure to be followed in applying for these scholarships may be obtained by writing to the Leonard Foundation, c/o Canada Permanent Trust Co., 320 Bay Street, Toronto 1.

THE J. EDGAR MC ALLISTER FOUNDATION

Through the generosity of the late J. Edgar McAllister, a graduate of the Faculty in 1891, a fund has been established in the University to be known as the J. Edgar McAllister Foundation, to provide financial aid for students who require it, in Mechanical, Chemical, Electrical and Metallurgy and Materials Science. Inquiries should be made in the Faculty Office.

THE JOHN WOLFE MC COLL MEMORIAL AWARDS

These six awards, two of which are open to students in the Faculty of Applied Science and Engineering, are the gift of the estate of the late John Wolfe McColl. The awards have a minimum value of $250 and a maximum of $750. Applicants must have obtained First Class Honours at the final examinations of the preceding year, whether Ontario Grade XIII or at the University of Toronto, demonstrate financial need and be enrolled or undertake to enrol in either Engineering Science or Chemical Engineering. Students seeking first admission to the University must submit applications for an award to the Office of Student Awards on or before May 1. Students in the University must submit applications for an award to the Registrar of the University on or before October 15.

THE J. A. D. MC CURDY PRIZE

The J. A. D. McCurdy Prize of a value of $75 was established by the trustees of a fund created by the members of the Number 3 Squadron, University Air Training Corps (1941–44) in honour of John Alexander Douglas McCurdy, a graduate of the School of Practical Science, who "made the first flight in Canada on February 23, 1909, with a heavier-than-air machine."

It is awarded annually to the student registered in Third Year, Aeronautics Option, in Engineering Science, who, taking honours, ranks highest in annual examinations of the Third Year in the subjects related to Aerodynamics.

The first award was made on the results of the examinations of the Session 1953–54.

THE GARNET W. MCKEE-LACHLAN GILCHRIST SCHOLARSHIP IN ENGINEERING SCIENCE

Mrs. Garnet W. McKee and Professor Lachlan Gilchrist each contributed $1,000 to provide for a Scholarship in the First Year of the Course in Engineering Science. The value of the Scholarship is the annual income from the capital fund and is awarded to the student who ranks first in honours at the annual examinations of the First Year in the Course in Engineering Science. If for any reason that student is ineligible to hold the Scholarship, it will be awarded by reversion to the student ranking second in honours in the Course. In order to receive payment the winner must register in the Second Year of the Course in Engineering Science. The Scholarship was awarded for the first time on the results of the annual examinations of 1947.

THE GARNET W. MC KEE-LACHLAN GILCHRIST GEOPHYSICS SCHOLARSHIPS

Financial assistance was received by Professor Lachlan Gilchrist of the Department of Physics, University of Toronto, from certain organizations and individuals to help him in the prosecution of his research work in Geophysics. With the consent of the contributors, the unexpended balance of these gifts was transferred by Professor Gilchrist to the Board of Governors of the University to be used as an endowment for scholarships, two of which were established in the Faculty of Applied Science and Engineering. To this fund have been added additional amounts received from the estate of the late Garnet W. McKee and from the Hollinger Consolidated Gold Mines Ltd. They are awarded by the Senate, on the recommendation of the Council of the Faculty of Applied Science and Engineering. The first awards were made on the results of the Annual Examinations of 1941.

The First Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $200 is awarded to the student in the Second Year in the Course of Engineering Science who obtains the highest aggregate standing at the examinations of the First and Second Years in the Course, provided always that the student obtains honour standing at the examinations of the Second Year.

The Second Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $165 is awarded to the student in the Second Year in the Course of Engineering Science who, of those students who elect to proceed in the Third Year in the Geophysics Option of the Course, obtains the highest aggregate standing at the examinations of the First and Second Years, provided always that the student obtains honour standing at the examinations of the Second Year, and excluding always the student to whom the First Lachlan Gilchrist Geophysics Scholarship has been awarded.

If in any year there is no student who has fulfilled the condition as laid down for the Second Lachlan Gilchrist Geophysics Scholarship, it shall be awarded to the student in the Second Year in the Course in Engineering Science who obtains the second highest aggregate standing at the examinations of the First and Second Years of that Course, provided always that such student obtains honour standing in the examinations of the Second Year.

LACHLAN DALES MC KELLAR ADMISSION SCHOLARSHIPS

Provided by a bequest of the late Leona D. McKellar, two scholarships of the value of $500 each, are offered to students who have achieved high standing on the Ontario Secondary School qualifications required for admission to the Faculty. Application must be made on the regular admission scholarship application form.

THE ALEXANDER MAC LEAN SCHOLARSHIP

This scholarship was established by graduates of the University of Toronto and other friends in honour of Professor Alexander MacLean, B.A. (1908) who retired in 1954.

The scholarship, of the value of $250, is awarded to a student in the Third Year of Geological Sciences, Faculty of Arts, or in the Third Year of Geological Engineering, Faculty of Applied Science and Engineering, who, obtaining not less than 75% in the work of the year, obtains the highest standing in the geological subjects common to the two courses.

The first award was made in 1955.

MAC LENNAN-MAC LEOD MEMORIAL PRIZE

The Graduating Class of 1910 has donated an annual prize, known as "The MacLennan-MacLeod Memorial Prize", in memory of their first Class President, George MacLennan, who was killed in action in France in 1917, and of Doug. MacLeod, their first Secretary, who died in France in 1916 from wounds received in action.

The prize, of the value of $25, is awarded to the First Year student in the Faculty of Applied Science and Engineering who ranks highest in Calculus among those who obtain standing without condition at the annual written examinations; or, in the event of more than one student obtaining equally high rank in Calculus, the award is made to the one of these who also has the highest standing in some other subject common to the competitors, such as Analytical Geometry, such subject to be determined by the Council of the Faculty.

An award will not be made in any year in which, in the opinion of the Council, no student obtains a sufficiently high standing in Calculus to merit the award. If in any year no award is made, a second award will be available in subsequent year.

CHARLES GORDON MANNING PRIZE

The Charles Gordon Manning Prize was established by a bequest under the Will of the late Jennie Manning in the amount of $500, the annual income from which is to be used to buy books for the winner of the Prize.

The recipient must be enrolled in the Second Year of a course offered by the Faculty of Applied Science and Engineering and, in the opinion of the Council, rank second to the student awarded the Harvey Aggett Memorial Scholarship in the considerations specified for the award of that Scholarship, namely, obtaining honours in his final examinations and being one of the first three in his year by his standing at those examinations relative to the pass requirements in his Department and being "adjudged highest of the three in general student activities and service in the University during his period of attendance."

The first award was made on the results of the Annual Examinations of 1954.

MARSLAND ENGINEERING LIMITED SCHOLARSHIP

The Marsland Engineering Limited Scholarship, the gift of Marsland Engineering Limited, has a value of $250. It is awarded to the student who, having been granted a Dominion-Provincial Student Aid Bursary in his First Year, is registered in Mechanical or Electrical Engineering and obtains the highest average percentage of marks, with honours, at the annual examination of the First, Second or Third Years in the session in which the award is made.

The first award was made at the annual examinations of 1954.

MASSEY-FERGUSON LIMITED SCHOLARSHIPS

Massey-Ferguson Limited has established two scholarships each of an annual value of $250, to be awarded on the recommendation of the Council of the Faculty of Applied Science and Engineering to students registered in the Fourth Year of the Courses in Mechanical Engineering or Industrial Engineering. In making the award academic achievement, financial need, extra-curricular activities and such other factors as may be deemed appropriate will be taken into consideration.

Application should be made to the Secretary of the Faculty not later than October 15.

JAMES L. MORRIS MEMORIAL PRIZE

The James L. Morris Memorial Prize is the gift of Mrs. J. H. Craig and Mr. J. R. Morris, K.C., in memory of their father, James L. Morris, C.E., O.L.S., D.Eng., the first graduate of the School of Practical Science, who died in 1946 after a distinguished career. Graduating in Civil Engineering in 1881 as the sole member of his class, Dr. Morris engaged in railway work for some time, first as an engineer and then as a contractor. For 43 years he conducted a successful civil engineering practice in Pembroke, Ontario, involving important undertakings in the field of municipal, power and bridge work.

This Prize, of the value of the annual income from $3,000, is awarded annually to the student in the Second Year of the Course in Civil Engineering who obtains the highest aggregate percentage at the annual examinations of the First and Second Years of the course, provided always that the student obtains honour standing at the Examinations of the Second Year.

OTTO HOLDEN SCHOLARSHIP

Otto Holden, B.A.Sc., C.E., D.Eng., was a distinguished hydraulic engineer of international reputation. He served Ontario Hydro for 47 years and retired as Chief Engineer in 1960, having been involved in almost all of the major hydro-electric developments in Ontario. On his death Mr. Holden left a sum of money which was later augmented by his widow, the late Florence Holden, to establish a scholarship in the Faculty of Applied Science and Engineering. This scholarship, which has a value of approximately $750 is awarded to the student who, completing the Fourth Year in Civil Engineering or Mechanical Engineering with Honours, obtains the highest aggregate marks in hydraulic engineering subjects in the Third and Fourth Years of the course. The first award was made in the session 1967/68.

THE ONTARIO HOCKEY ASSOCIATION WAR MEMORIAL SCHOLARSHIP

The Ontario Hockey Association War Memorial Scholarship, the gift of the Ontario Hockey Association, is to be awarded annually at the Grade XIII examination to an applicant whose father served overseas with the Canadian Forces in World War I.

The value of this scholarship is $100 in cash, with an allowance of the same amount on the tuition fee for each session.

In determining the award of the scholarship, the academic qualifications of the candidate shall be first taken into account, provided always that no candidate shall be eligible for an award who has not met all the conditions required by the University of candidates for admission scholarships generally; but, *cœteris paribus,* the award shall be made to a student who is in proved need of assistance.

The award shall be made by the Senate of the University upon the report of a committee to be appointed by the Senate, upon which committee there shall be always one member of the Staff of the University who shall be deemed to be representative of the Association.

Application should be made to the Office of Student Awards on the regular scholarship application form not later than May 1.

ORENDA LIMITED SCHOLARSHIPS

Orenda Limited has donated three scholarships each of a value of $500, awarded annually to students completing the First, Second and Third Years respectively in courses other than Geological Engineering. These scholarships are awarded to students with high academic standing and in cases of close competition, preference will be given to the student who indicates that he possesses initiative and leadership qualities and that he will be a credit to his profession after graduation.

This award may be held with other awards provided that the monetary value of the other awards does not exceed $100. The first award was made in the Session 1955–56.

PAULIN MEMORIAL SCHOLARSHIP

The Paulin Memorial Scholarship, provided through the generosity of the late Mr. Fred W. Paulin, a graduate of this Faculty in 1907, was established in memory of his brother, John Cameron Paulin, a student of this Faculty, who was fatally injured in 1906 during a football practice. The scholarship, which has the value of the income from a capital fund of $10,000, approximately $475 annually, is awarded to a student who obtains high standing in the work of the first year in the Faculty of Applied Science and Engineering.

PROCTER AND GAMBLE BURSARY PLAN

Procter and Gamble Bursaries, the gift of the Procter and Gamble Company of Canada, are awarded annually to students in all years. Applicants must have at least

Second Class Honours or better in the final examinations of the preceding year and demonstrate financial need. Applications must be submitted to the Office of Student Awards on or before December 1.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO ADMISSION SCHOLARSHIP

The Ontario Professional Engineers Foundation for Education provides an admission scholarship of the value of $500. It is awarded to the candidate who obtains the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to the Council that his attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other Admission scholarship.

Application must be made to the Office of Student Awards before May 1.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO SCHOLARSHIPS

The Ontario Professional Engineers Foundation for Education offers scholarships of a value of $250 in each of the First, Second and Third Years in the Faculty of Applied Science and Engineering in any course, to the students who, taking Honours, obtain the highest standing in the work of their respective years.

These scholarships will not be awarded to students who hold other scholarships.

PROFESSIONAL ENGINEERS GOLD MEDAL

The Association of Professional Engineers of the Province of Ontario has established in the Faculty of Applied Science and Engineering an award in the form of a gold medal accompanied by a gift of technical books of an approximate value of $50. The award will be made to the student of the final undergraduate year in any course who, taking honours, obtains the highest weighted average percentage in the practical work and written examinations of the year.

RANSOM SCHOLARSHIP IN CHEMICAL ENGINEERING

The Ransom Scholarship in Chemical Engineering is presented by A. C. Ransom, Esq., of Toronto, for the purpose of encouraging and giving financial assistance to students who choose the field of Chemical Engineering. This donation, consisting of $5,000, provides for a perpetual scholarship of an annual amount such as will be derived from the income of this sum. The first award was made on the results of the annual examinations of 1938.

The scholarship will be awarded annually to the student registered in the Course in Chemical Engineering who obtains the highest aggregate percentage of marks in the examinations of the First Year. The scholarship will be paid to the winner only if he proceeds to take his Second Year in the Course in Chemical Engineering in the University of Toronto.

J. E. REID MEMORIAL PRIZE

This prize, established in 1967 in memory of the late Professor J. E. Reid, is awarded to the student in the Fourth Year of the course in Electrical Engineering who, graduating with honours, achieves the highest aggregate marks in the Fourth Year examinations in the subjects pertaining to electronic communication.

THE RHODES SCHOLARSHIPS

The Rhodes Trustees offer for award in the Province of Ontario two out of ten of the Rhodes Scholarships for Canadians, each of the value of £1,000 and tenable at Oxford University for a period of two years; in certain cases, a third year may be authorized.

Each candidate must be a British subject with at least five years domicile in Canada and unmarried; he must have passed his nineteenth but not twenty-fifth birthday on October 1 of the year *for* which he is elected; he must have completed the first year of his course at a Canadian university at the time of application.

A candidate may apply either for the province in which he has his private home or residence, or for the province in which he has taken his university course.

In that section of the will in which he defined the general type of scholar he desired, Mr. Rhodes mentioned four groups of qualities, the first two of which he considered most important.

(1) Literary and scholastic attainments;
(2) Qualities of manhood, truth, courage, devotion to duty, sympathy, kindliness, unselfishness, and fellowship;

The scholarship will be awarded annually to the student registered in the Course in

(3) Exhibition of moral force of character and of instincts to lead and to take an interest in his fellows;
(4) Physical vigour, as shown by fondness for and success in outdoor sports.

Some definite quality of distinction, whether in intellect, character or personality, or in any combination of these, is the most important requirement. Financial need does not receive special consideration.

Forms of application and full information regarding these scholarships may be obtained from the Registrar, University of Toronto, or from J. L. Stewart, Esq., General Secretary for the Rhodes Scholarships in Canada, 14th floor, 320 Bay St., Toronto 1. Selection is made in December for the following year and all applications must reach the provincial secretary before November 15 annually.

R.C.E. MEMORIAL SCHOLARSHIP

The Memorial Fund Committee of the Royal Canadian Engineers has established the R.C.E. Memorial Scholarship of a value of $125, open to students who have successfully completed their second to last year in the Faculty of Applied Science and Engineering or the School of Architecture.

A candidate must be

(*a*) a member in good standing of the Canadian Officers Training Corps and have successfully completed one summer season's training, or

(*b*) an ex-member of the Canadian Officers Training Corps who has successfully completed two years of C.O.T.C. Training and has transferred to the Canadian Army (Militia) or to the Canadian Army (Supplemental Reserve), or

(*c*) a member of the Canadian Army (Regular) attending University under the Regular Officers Training Plan.

Selection is made on the basis of academic standing and of qualities of leadership.

Application forms may be obtained from the Office of Student Awards.

REGULAR OFFICER TRAINING PLAN

Tenable in approved degree courses, this plan is available to Canadian citizens who undertake to serve in the armed forces for at least four years after graduation. Accepted candidates will receive tuition, a book allowance of $125 and a living allowance of $193 per month during the academic session.

Application should be made to the Canadian Forces Recruiting Centre, 25 St. Clair Avenue West, Toronto 7.

HELEN E. ROGERS ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of Helen E. Rogers open to students entering any degree course in the University. Preference is given to applicants from outside Ontario but failing such candidates awards may be made to qualified Ontario students. Recipients must have a standing satisfactory to the Committee of Award on first admission and may continue to enjoy the scholarship in the upper years provided they maintain first class standing. The value in each year is a minimum of $200 and a maximum of $1,500 dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards by May 1 on the regular admission scholarship application form.

DON SALT MEMORIAL SCHOLARSHIPS

In memory of Donald John Salt, a graduate of the Faculty of Applied Science and Engineering and a practising geophysicist, the Canadian Exploration Geophysical

Society has provided two scholarships of the value of $500 which are open to students in the Third and Fourth Years of certain courses in the Faculty of Arts and Science, and in Geological Engineering and the Geophysics option of Engineering Science in the Faculty of Applied Science and Engineering.

The award is made on evidence of the interest and ability of the applicant in relation to the field of mining geophysics.

Application should be made either to the Chairman of the Department of Physics or the Chairman of the Department of Geology by March 1 in the calendar year in which the award is to be made.

FREDERICK W. SCHUMACHER SCHOLARSHIP

The Frederick W. Schumacher Scholarship has been awarded in the Faculty of Applied Science and Engineering and in the Faculty of Arts under a bequest of the late Frederick W. Schumacher. It has a value of the income from the fund. The scholar must (*a*) be enrolled in the Second, Third or Fourth years in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and (*b*) must have high academic standing.

Applications must be submitted to the Office of Student Awards not later than October 15.

"SECOND MILE ENGINEER" AWARD

The Class of 3T5, convinced that a successful engineer must not only be professionally competent but also constantly aware of his responsibilities to humanity, and inspired by an address of President William E. Wickenden of the Case School of Applied Science, Cleveland, called "The Second Mile," which was based on the text from the Sermon on the Mount, "whosoever shall compel thee to go one mile, go with him twain" has established the "Second Mile Engineer" award. It is the desire of the donors to encourage undergraduates to participate fully in extra-curricular activities and to recognize the true importance of the more liberal subjects of the curriculum with the ultimate objective, on entering the profession, of becoming worthy Second Mile Engineers. The award comprises a grant of $200, a suitably inscribed presentation piece and an illuminated scroll, and is presented to a student in his final year.

An eligible group is chosen from those who have taken a prominent part in the affairs of the Faculty, either as office holders or in athletics. In making the award consideration is given to academic standing, with special emphasis on the candidate's attainments in the cultural and humanistic-social studies.

Particulars are furnished each session by the Class of 1935.

THE SIMPSONS-SEARS LIMITED (NORTHERN ONTARIO) SCHOLARSHIPS

These scholarships, the gift of Simpsons-Sears Limited, are open only to students of the Copper Cliff High School, The Sudbury High and Technical Schools, the Sturgeon Falls High School, the North Bay Collegiate Institute and Vocational School, the Kapuskasing High School and all the Secondary Schools along the Ontario Northland Railway. A scholarship of the value of $100 is available for each of the schools mentioned and an additional sum of $50 will be given to the student who obtains the highest percentage of the nine papers of Grade XIII selected in accordance with the regulations.

No scholarship will be awarded unless the candidate is in actual attendance in one of the colleges or faculties of the University and maintains a uniformly high standard to the satisfaction of the donors of the scholarships.

Application for these scholarships must be sent not later than May 15, to the Principal, Algonquin Composite School, North Bay, from whom further information may be obtained regarding conditions of award.

WALLACE AWARD
SOCIETY OF AUTOMOTIVE ENGINEERS PRIZE

In memory of William Wallace, Professor of Mechanical Engineering, University of Toronto, the Ontario Society of Automotive Engineers offers an annual prize of the value of $100 to a student of the Fourth Year in any course whose thesis on a topic related to Automotive Engineering is considered by the Head of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory.

SOCIETY OF CHEMICAL INDUSTRY MERIT AWARD

The Society of Chemical Industry Merit Award is made annually by the Society to the student in Fourth Year in the Department of Chemical Engineering who obtains the highest weighted average of marks in the results of the annual examinations for the year. The award is a gold key.

THE MURRAY F. SOUTHCOTE SCHOLARSHIP

Established by friends of the late Murray F. Southcote, a graduate of this Faculty (Aeronautical Engineering, 1950) this scholarship, which has a value of $100, is awarded in recognition of high standing at the Annual Examinations of the Third Year, in any course in the Faculty.

The first award was made in the Session 1964–65.

SPRUCE FALLS POWER AND PAPER COMPANY LIMITED SCHOLARSHIPS

The Spruce Falls Power and Paper Company Limited has established four Scholarships of a value of $400 each, two in the Second Year and two in the Third Year. They are awarded on the results of the Annual Examinations of the Second and Third Years to the students who obtain honour standing at the examinations of their respective years and are open to students in all courses in the Faculty. The first awards were made on the results of the examinations of 1951.

Each scholarship carries a grant of $150 to the University General Funds.

WALTER STERLING ADMISSION SCHOLARSHIPS

Established in memory of Walter Sterling, these scholarships are open to students entering any first degree course at the University of Toronto. Recipients must obtain First Class Honours standing on the nine Ontario Grade XIII papers required for admission, and may continue to enjoy the scholarships in each year of their course providing they maintain Honour standing. The value of the scholarship is from $200 to $1,500 annually, dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards on the regular scholarship application form. The statement of financial need should be completed if an award greater than $200 is desired.

THE WILLIAM STORRIE MEMORIAL SCHOLARSHIPS IN CIVIL ENGINEERING

Three Scholarships have been established by Mrs. William Storrie in memory of her husband, the late William Storrie, a Consulting Engineer on many municipal projects in Canada and for several years a special lecturer in the Faculty of Applied Science and Engineering, for students in Civil Engineering, as follows:

(*a*) Of a value of $100 to a student who obtains high standing in the annual examinations of the Second Year in Civil Engineering.

(*b*) Of a value of $100 to a student who obtains high standing in the annual examinations of the Third Year in Civil Engineering.

(*c*) Of a value of $200 to the student who obtains the highest standing in the annual examinations of the Fourth Year in the Municipal and Sanitary Option of the course in Civil Engineering.

In all cases the candidates shall have demonstrated qualities of integrity and shown promise of leadership in their profession.

The first awards were made for the Session 1956–57.

EDITH TYRRELL MEMORIAL BURSARY

The Women's Association of the Mining Industry of Canada has presented this Bursary, having the value of $600, annually, commencing in 1939, and named in memory of their founder and first president, Mrs. Edith Tyrrell. A medal donated by Dr. Tyrrell accompanies this Bursary. The Bursary is awarded to a student entering the Third or Fourth Year in the Course of Metallurgy and Materials Science, or Geological Engineering; it may be awarded two years in succession to the same student, but will usually be awarded at the beginning of the Third Year. The award will be made by a special committee appointed by the Association on the following basis:

(*a*) In addition to mental capacity, the student must show leadership ability and give promise, through his activities, of becoming a worthwhile influence in the affairs of the profession and the community.
(*b*) While attention is given to scholastic ability, as evidenced by his academic standing, it is not the governing factor. He must, however, stand in the top quarter of his class.
(*c*) Special consideration is given to financial need.

Application must be made to the Secretary of the Faculty within one month of the opening of the academic year.

S. UBUKATA FUND

The S. Ubukata Fund for Japanese students was established to assist students from Japan proper to pursue a course of study at the University of Toronto. The fund provides grants of varying values on the basis of the information submitted by the applicants who:
(*a*) must be Japanese students from Japan proper;
(*b*) must register in the University of Toronto devoting full time to their studies;
(*c*) are able to satisfy admission requirements regarding English facility;
(*d*) are not holding other financial aid.

UNIVERSITY OF TORONTO ALUMNI ASSOCIATION WAR MEMORIAL SCHOLARSHIPS

Six scholarships are awarded annually by the University of Toronto Alumni Association to students entering first degree courses at the University of Toronto. The scholarships have a value of $500 annually, and are tenable for two years, providing satisfactory academic standing is maintained. They are awarded for general proficiency in Grade XIII, and in addition to academic performance the committee of award will take into consideration the candidate's relationship to active service in the Armed Forces of Canada, need of financial assistance, participation in extra-curricular activities and such other qualifications as may commend themselves to the committee. One scholarship will be available to a student whose home is not in the Province of Ontario.

Students resident in Ontario may apply on the general admission scholarship form which must be submitted to the Registrar of the University not later than May 1. Evidence of relationship to active service in the Armed Forces of Canada should be attached. Students resident outside Ontario may obtain the necessary forms from the Office of Student Awards, University of Toronto.

THE U.T.S. ENGINEERING SCHOLARSHIP

The U.T.S. Engineering Scholarship, the gift of R. A. Bryce, Esq., of the value of $250. The scholarship will be awarded by a committee of the Staff of the University of Toronto Schools to a student of the Schools who has completed the requirements for admission to and enrols in the Faculty of Applied Science and Engineering.

WALLBERG ADMISSION SCHOLARSHIPS

Two admission scholarships, each of a value of $500 are awarded annually from the income from the Wallberg Bequest on the recommendation of the Council of the Faculty to the two candidates who obtain the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to Council that this attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other Admission scholarship.

Applications must be submitted to the Office of Student Awards on the prescribed form by May 1.

WALLBERG UNDERGRADUATE SCHOLARSHIPS

These scholarships, four in number, of the value of $500 each, derived from the Wallberg Bequest, are awarded annually; two to students ranking first and second respectively at the annual examinations of the First Year; one to the student ranking first at the annual examinations of the Second Year; and one to the student ranking first at the annual examinations of the Third Year.

Any holder of one of these scholarships may not hold other awards listed in the index with an asterisk. The awards were first made on the result of the annual examination of 1947.

W. S. WILSON MEDALS

These medals have been provided in recognition of the service to the Faculty of Applied Science and Engineering of its former Assistant Dean and Secretary, William Stewart Wilson.

A medal will be awarded to the student in each graduating course, who, attaining Honours, achieves the highest standing in the final year of his course.

The first awards were made in the Session 1962–63.

WILLIAM R. WORTHINGTON MEMORIAL SCHOLARSHIP

The William R. Worthington Memorial Scholarship, the gift of Miss Ida R. Worthington, in memory of her brother, William R. Worthington, DIP.(1904), B.A.SC.(1905), of the value of the income from a fund is awarded annually to the student of the Second Year in the course in Civil Engineering who ranks highest at the annual examinations of that year.

The first award was made at the examinations for the Session 1954–55.

LOAN FUNDS

From the loan funds mentioned below, small loans can be made to students who are in urgent need of assistance. The funds are not large and the loans must accordingly be restricted, both in amount and number, and principally to students in the Third and Fourth Years.

Enquiries for loans from any of the following funds should be made at the office of the Secretary of the Faculty.

Engineering Society Loan Fund
Elizabeth Speller Memorial Fund
James W. Crocker Memorial Fund
Harry F. Bennett Educational Fund
S.A.E. – Canadian Section Loan Fund
Class of 2T7 (SPS) Memorial Loan Fund
Avro Aircraft Limited Engineering Loan Fund
The William Storrie Memorial Fund
3T6 Engineers Loan Association
4T0 Engineering Loan Fund
Women's Association of the Mining Industry in Canada Loan Fund
The Devonshire Loan Fund
Class of '09 Trust Fund
University of Toronto Alumni Loan Fund

CLASS OF 1936 LOAN ASSOCIATION

Members of the Class of 1936 have made arrangements to assist students in obtaining loans through regular banking facilities. Information may be obtained from the Secretary of the Faculty.

ENGINEERING SOCIETY LOAN FUND

In 1932 the Engineering Society repaid to the Board of Governors a series of annual grants which, over a period of years, had been made to the Society for special purposes. The Board of Governors, appreciating this action, set aside this sum, to be known as the Engineering Society Loan Fund, to provide loans to students of the Faculty of Applied Science and Engineering. The administration of the fund is carried out by a Committee appointed by the Board. The fund is not large, and only small loans can be made to relatively few students. Further inquiries should be made at the office of the Secretary of the Faculty.

ELIZABETH SPELLER MEMORIAL FUND

Through the generosity of Dr. F. N. Speller, of the Class of 1893, the "Elizabeth Speller Memorial Fund" has been established to provide loans for worthy students of the Third and Fourth Years of this Faculty. Applications for loans from this Fund should be made to the Secretary of the Faculty.

JAMES W. CROCKER MEMORIAL LOAN FUND

This fund was established by Mrs. William Crocker in memory of her son, James W. Crocker, a graduate in Mining Engineering in 1938, who was killed in an accident in a mine in the same year.

HARRY F. BENNETT EDUCATIONAL FUND

This fund was established by subscription from members of The Engineering Institute of Canada in memory of the late Harry F. Bennett, M.E.I.C., who for six years prior to his death in 1946 was chairman of the Institute's Committee on the Training and Welfare of the Young Engineer, and who accomplished so much in this field by untiring efforts.

One purpose of the fund is to make loans to deserving students who need financial assistance to enable them to study engineering sciences at university level, and who have proved themselves by successfully completing their first year in engineering or the equivalent.

Loans will be made largely on the basis of character and to men who seem likely to develop the high professional standards which are essential to leadership in engineering science. A student who has been aided by this fund should feel that high obligations are placed on him; obligations to the subscribers, to the trustees, and to those coming after him who in turn can receive help as his loan is repaid.

Application forms may be obtained at the Faculty Office. The regulations are simple and the application of any worthwhile student will be given immediate and careful attention.

SOCIETY OF AUTOMOTIVE ENGINEERS – CANADIAN SECTION LOAN FUND

The Society of Automotive Engineers – Canadian Section has established a loan fund of $1,200 in the Faculty of Applied Science and Engineering. Preference is given to students in good scholastic standing and engaged in studies relative to the automotive and aircraft industries, and to students in fourth, third and second years in that order. Particulars may be obtained from the Secretary of the Faculty.

AVRO AIRCRAFT LIMITED ENGINEERING LOAN FUND

Avro Aircraft Limited has established a Loan Fund of $3,000 to provide loans to engineering students requiring financial assistance. Application should be made to the Secretary of the Faculty.

THE WILLIAM STORRIE MEMORIAL FUND

The William Storrie Memorial Fund has been established by Mrs. William Storrie to provide loans to undergraduates in the course in Civil Engineering. Application should be made to the Secretary of the Faculty.

THE DEVONSHIRE LOAN FUND

This Fund has been established by Graduates and friends of Devonshire House to assist students in the Residence. Application should be made to the Office of the Dean of Devonshire House.

CLASS OF '09 TRUST FUND

The Class of '09 on the 50th Anniversary of their graduation made a sum of money available in the Faculty for financial aid to undergraduates, with preference to Second Year students. Inquiry should be made to the Secretary of the Faculty.

THE UNIVERSITY OF TORONTO ALUMNI LOAN FUND

This fund comes from subscriptions received originally in 1919 and in succeeding years from graduates of the University and is administered by the University of Toronto Alumni Association.

Loans are available to undergraduate and graduate students enrolled in a full time course at the University, in second and subsequent years.

Particulars may be obtained from The University of Toronto Alumni Association, Alumni House, Willcocks Street, Toronto.

IX Discipline

A SUMMARY OF THE REGULATIONS OF THE CAPUT CONCERNING STUDENT DISCIPLINE

1. Subject to the general regulations of the Caput of the University regarding jurisdiction in matters of discipline the Council of University College, the governing bodies of the Federated Universities and Affiliated Colleges, and the Councils of the Faculties, Schools, and Institutes have disciplinary jurisdiction over the conduct of all students registered in these Divisions of the University in all matters of local or internal concern to these Divisions. Jurisdiction over the conduct of students while in residence regardless of the Division of the University in which they are registered is vested in the body administering the residence.

2. Jurisdiction concerning conduct likely to affect the interests of the University as a whole is vested in the Caput.

3. The Students' Administrative Council will be supported in the proper performance of all its obligations and duties as provided in its Constitution.

4. Where the appropriate body exercising disciplinary jurisdiction has found that a student of the University has engaged in conduct prejudicial to the interests of the University, the Caput may, in its discretion, suspend or expel such student from the academic privileges of the University. Every decision of the Caput involving the expulsion of a student from the University requires confirmation of the Board of Governors.

5. Any student who interferes with the personal liberty of another or who subjects another student to indignity or personal violence may be considered by the Caput or any other body exercising disciplinary jurisdiction in the University to have committed a breach of discipline.

6. Initiation ceremonies involving physical violence, personal indignity, interference with personal liberty, or destruction of property, may be deemed a breach of discipline by the Caput or any other body exercising disciplinary jurisdiction in the University.

7. Without limiting the disciplinary powers vested in the respective bodies exercising disciplinary jurisdiction as set forth in sections 1–7, the following are cited as illustrations of conduct which, in the past, has been considered a breach of discipline prejudicial to the interests of the University:

(i) The organising of a parade on the streets of the city or the taking part in such a parade without permission of the authorities.

(ii) The destruction or defacing of University property, raids on Residences or other University buildings, and the breaking into University buildings.

(iii) Rowdy and other forms of behaviour, either on or off the Campus, of such an objectionable nature as to bring the University into public disrepute.

8. Student Clubs and Associations

(a) The constitution of every society or association of students in the University and all amendments to such constitutions require to be approved by the relevant University authorities. The giving of approval, and the responsibility for the programmes of student societies and associations, shall rest as follows:

(i) With the authorities of the College, Faculty or School concerned where the membership of the student society or association is drawn from a single College, Faculty or School.

(ii) With the Board of Stewards of Hart House, where the student society or association is a Committee of Hart House and is controlled by the Board of Stewards of Hart House.

(iii) With the Caput, in the case of all other student societies and associations.

(b) No approval will be given by any of the authorities listed in (a) above to the constitution of any society or association of students if that constitution permits:

(i) Membership in the society or association to persons who are not students of the University, unless in the case of the societies listed in (a) (ii) above, where membership is open also to graduates of the University and members of the Faculty of the University.

(ii) Any action of discrimination based upon race, religion, or colour.

9. The name of the University is not to be used in connection with a publication of any kind without permission of the Caput.

X Professores Emeriti

DEAN EMERITUS

R. R. McLaughlin, M.A.SC., M.A., PH.D., D.SC.,
Professor Emeritus of Chemical Engineering

PROFESSORES EMERITI

E. A. Allcut, M.SC.(BIRM.), M.E., F.R.AE.S.,
Professor Emeritus of Mechanical Engineering

W. B. Dunbar, B.A.SC.,
Professor Emeritus of Engineering Drawing

C. E. Helwig, M.A.SC.,
Professor Emeritus of Civil Engineering

K. B. Jackson, B.A.SC., D.SC.(WATERLOO),
Professor Emeritus of Applied Physics

O. J. Marshall, B.A.SC., C.E., O.L.S.,
Professor Emeritus of Civil Engineering

W. G. McIntosh, B.A.SC.,
Professor Emeritus of Mechanical Engineering

J. W. Melson, B.A.SC.,
Professor Emeritus of Surveying and Geodesy

C. F. Morrison, B.E.(SASK.), M.SC.(MCG.),
Professor Emeritus of Civil Engineering

L. M. Pidgeon, M.B.E., B.SC.(OXON.), PH.D.(MCG.), F.R.S.C.,
Professor Emeritus of Metallurgical Engineering

E. A. Smith, M.A.(MCM.),
Professor Emeritus of Chemical Engineering

V. G. Smith, B.A.SC.,
Professor Emeritus of Electrical Engineering

G. F. Tracy, B.A.SC., S.M.(M.I.T.),
Professor Emeritus of Electrical Engineering

A. Wardell, B.A.SC.,
Professor Emeritus of Engineering Drawing

W. J. T. Wright, M.B.E., B.A.SC., B.A.,
Professor Emeritus of Engineering Drawing

XI

Administrative Officers

1969–70

THE UNIVERSITY

President: C. T. Bissell, M.A., PH.D., D. ÈS L., D.LITT., LL.D., F.R.S.C.
Acting President: J. H. Sword, M.A. *(1967–68 Session)*
Vice-Provost and Executive Assistant to the President: D. F. Forster, B.A., A.M.
Assistant to the President: N. S. C. Dickinson, C.D., B.A.

Vice-President and Provost: M. St. A. Woodside, M.A., LL.D.

Vice-President (Health Sciences): J. D. Hamilton, M.D., F.R.C.P.(C.)
Vice-President (Research Administration):
G. de B. Robinson, M.B.E., B.A., PH.D., F.R.S.C.

Chief Librarian: R. H. Blackburn, M.A., B.L.S., M.S., LL.D.

Executive Vice-President (Non-Academic): A. G. Rankin, B.COM.
Vice-President (Administration): F. R. Stone, B.COM., C.A.
Financial Analyst: G. L. Court, D.F.C., M.COM., C.A.
Secretary of the Board of Governors and
Director of Administrative Services: D. S. Claringbold
Director of Physical Plant: F. J. Hastie, B.SC., P.ENG.
Vice-President and Registrar: R. Ross, M.B.E., M.A.
Executive Assistant to the Vice-President and Registrar: W. Kent, M.A.

Director of Admissions: E. M. Davidson, B.A.
Director of Student Awards: Miss H. L. Reimer, B.A., B.PED.
Special Officer (Secondary School Liaison): J. R. H. Morgan, M.B.E., M.A., B.PAED., LL.D.
Director of Statistics and Records: J. H. Tusiewicz, M.A.SC., M.B.A.
Director of University Health Service: G. E. Wodehouse, M.C., M.D., F.R.C.P.
Assistant Director of University Health Service–Women: Miss F. H. Stewart, B.A., M.D.
Director of Placement Service: A. W. Headrick, M.A.
Director of International Student Centre: Mrs. K. Riddell, B.A.
Director of the Advisory Bureau: D. J. McCulloch, B.A., M.D., D.PSYCH., F.R.C.P.
Director of Housing Service: Mrs. M. G. Jaffary, B.A.

Director of University Extension: G. H. Boyes, M.A.
Director of University of Toronto Press: M. Jeanneret, B.A., LL.D.
Director of Information: K. S. Edey
Director of Alumni Affairs: J. C. Evans, B.A.
Director of Development: R. J. Albrant
Warden of Hart House: E. A. Wilkinson, B.A.
Director of Athletics and Physical Education – Men: W. A. Stevens, B.S.
Director of Athletics and Physical Education – Women (Acting):
Miss A. Hewett, B.ED., P.E.

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The University of Toronto issues the following calendars and other publications concerning courses of instruction given by the University, any one of which may be had on application to the Office of Admissions of the University, or to the Secretary of the Faculty, School or Institute about which information is sought.

GENERAL INFORMATION:	University of Toronto Handbook
ADMISSION INFORMATION:	Admission Awards
	Admission Circular
APPLIED SCIENCE AND ENGINEERING:	Faculty of Applied Science and Engineering
	Engineering at Toronto – descriptive brochure
ARCHITECTURE:	School of Architecture
	Landscape Architecture – descriptive brochure
	Graduate Work in Architecture – descriptive brochure
ARTS AND SCIENCE:	Faculty of Arts and Science
	Courses and Subjects in Arts and Science
	Diploma Course in Computing and Data Processing
BUSINESS:	School of Business – Graduate Programme in Business Administration
CHILD STUDY:	Institute of Child Study
DENTISTRY:	Faculty of Dentistry
	Courses for Graduates in Dentistry
	Dental Hygiene
EDUCATION:	The College of Education
	Graduate Degrees in Education*
EXTENSION:	Degree Courses in Extension
	Certificate Course in Business
	Certificate Course in Public Administration
	Certificate Course in Criminology
	Evening and Afternoon Courses in the Liberal Arts
	Business and Professional Courses
	Correspondence Courses
	Pre-School Education
FOOD SCIENCES:	Faculty of Food Sciences
FORESTRY:	Faculty of Forestry
GRADUATE STUDIES:	School of Graduate Studies
HYGIENE:	School of Hygiene
LAW:	Faculty of Law
LIBRARY SCIENCE:	School of Library Science
MEDICINE:	Faculty of Medicine
	Division of Rehabilitation Medicine
	Division of Postgraduate Medical Education
MUSIC:	Faculty of Music
	The Royal Conservatory of Music
	School of Music Year Book
	General Syllabus
	Pianoforte and Theory Syllabus
NURSING:	School of Nursing
PHARMACY:	Faculty of Pharmacy
PHYSICAL AND HEALTH EDUCATION:	School of Physical and Health Education
SOCIAL WORK:	School of Social Work

*Write to: Ontario Institute for Studies in Education, 102 Bloor Street West, Toronto 181, Ontario.

NOTES

NOTES

NOTES

University
of Toronto

Faculty of
Applied Science
and Engineering

Calendar 1971-1972

University of Toronto Press
1971

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Calendar 1971-1972

FALL TERM, 1971

July 1	Thursday	Dominion Day, Buildings closed.
August 2	Monday	Civic Holiday, Buildings closed.
August 23	Monday	Students entering III Civil Engineering report at Survey Camp.
August 31	Tuesday	Meeting of Faculty Council.
September 1	Wednesday	*Registration of First Year students, from 9:30 a.m. to 4:30 p.m.
September 2	Thursday	*Registration of Second Year students, from 9:30 a.m. to 12:00 noon. *Registration of Third Year students, from 2:00 p.m. to 4:30 p.m.
September 3	Friday	*Registration of Fourth Year students, from 9:30 a.m. to 12:00 noon. *Students who reside outside Metropolitan Toronto may register on Tuesday, September 7, 1971, without penalty.
September 6	Monday	Labour Day. Buildings closed.
September 8	Wednesday	Lectures and laboratory work commence at 9:00 a.m.
September 24	Friday	Last day for students to add new courses to programs.
October 4	Monday	Meeting of Faculty Council.
October 11	Monday	Thanksgiving Day. Buildings closed.
October 27	Wednesday	Last date to drop a course without failure.
November 2	Tuesday	Meeting of Faculty Council.
November 11	Thursday	Remembrance Day.
December 1	Wednesday	Meeting of Faculty Council.
December 8	Wednesday	Last day of lectures in Fall Term.
December 9 to December 22	Thursday Wednesday	Study and examinations in Fall Term.
December 25	Saturday	Christmas Day. Buildings closed.

SPRING TERM, 1972

January 1	Saturday	New Year's Day. Buildings closed.
January 10	Monday	†Opening day of Second Term. Lectures and laboratory work commence at 9:00 a.m.
January 17	Monday	Meeting of Faculty Council.
January 21	Friday	Last date for students to add new courses to programs.
February 1	Tuesday	Meeting of Faculty Council.
February 21	Friday	Last date to drop a course without failure.
March 1	Wednesday	Meeting of Faculty Council.
March 31	Friday	Good Friday. Buildings closed.
April 5	Wednesday	Meeting of Faculty Council.
April 14	Friday	Last day of lectures in Spring Term.
April 17	Monday	
to		
April 28	Friday	Study and examinations in Spring Term courses.
May 3	Wednesday	Meeting of Faculty Council.

†Students taking elective courses in the Faculty of Arts and Science should note that lectures in that Faculty will commence on January 3, 1972. Also, examinations in Arts and Science courses may be scheduled later than April 28, 1972.

II

The Faculty of Applied Science and Engineering

ADMINISTRATIVE STAFF

Dean: J. M. Ham, B.A.SC., S.M., SC.D.(M.I.T.)
Executive Assistant and Secondary Schools Liaison Officer:
J. S. Hewitt, B.SC.(QU.), M.SC., PH.D.(BIRM.)
Associate Dean: G. B. Craig, M.A.SC., PH.D.
Assistant Dean and Secretary: J. A. Gow, B.A.SC.
Assistant Secretary: W. J. Dowkes, B.A.SC.

The Faculty of Applied Science and Engineering in the University of Toronto offers the widest range of undergraduate and postgraduate studies in engineering in Canada. The four year Bachelor of Applied Science (B.A.Sc.) undergraduate program is offered in Civil, Chemical, Electrical, Geological, Industrial and Mechanical Engineering, in Metallurgy and Materials Science and in Engineering Science. The Engineering Science program offers specific options in Aerospace, Chemical, Computer Science, Electrical, Geophysics, Materials Science, Nuclear and Thermal Power and Physics.

The Faculty offers, through the School of Graduate Studies, postgraduate programs for the Master of Applied Science (M.A.Sc.), the Master of Engineering (M.Eng.) and the Doctor of Philosophy (Ph.D.). Through the immense diversity of the resources of the University it is possible to do research in bio-engineering (engineering and medicine), in environmental engineering (urban planning and the control of pollution in air, water and land), in the history of technology, etc. This remarkable pattern of bridges linking the arts, sciences and professions in studies of man, his ideas and works adds a distinctive vitality and range to engineering at Toronto.

There are some 2200 undergraduate students and 600 postgraduate students. Undergraduates are taught not only by the staff of the Faculty but also by staff of University departments in Chemistry, Geology, Mathematics, Pysics, English, History, Philosophy and Political Economy. On the staff of the Faculty alone there are some 180 professors.

From its historic beginnings in the School of Practical Science (S.P.S.) in the eighteen-seventies, the Faculty has grown since 1906 as an integral and senior part of the University. For students an important historical fact is that the Engineering Society, the student society of the Faculty, with its "Cannon" and "LGMB" band, is the oldest engineering organization of any formal kind in Canada.

The Faculty is located on the main campus in a rectangle bounded on the south by College Street, the west by St. George Street, the north by Convocation Hall and on the east by Taddle Creek Road where, in the days of Canadian Confederation there was indeed a creek so named.

The administrative offices are located in the southwest corner of the Galbraith Building at 35 St. George Street. Students and visitors may obtain information and assistance here.

SUMMARY OF STUDENTS IN ATTENDANCE — *Session 1970–1971*

COURSE		1	3	4	5	6	7	8	9	TOTAL
Year	I	94	118	57	120	96	114	18	29	646
	II	69	83	70	86	63	113	19	16	519
	III	79	99	77	67	86	118	15	16	557
	IV	60	79	86	53	75	131	8	8	500
TOTAL		302	379	290	326	320	476	60	69	2222
Special Students										9

III

General Information Admission and Registration

ADMISSION REQUIREMENTS

1. Full details of the University of Toronto undergraduate admission requirements for 1972 are contained in the Undergraduate Admission Handbook 1972–73 available on request from the Office of Admissions, University of Toronto, Toronto 181, and in all Ontario secondary schools. The 1971 requirements follow.

2. ONTARIO GRADE 13 GENERAL REQUIREMENTS:

Entrance to the First Year of the undergraduate courses is offered, depending upon the number of places available, to candidates from Ontario secondary schools who demonstrate good standing, based upon the following evidence:

1. Completion of secondary school studies, including a full program of academic work at the Grade 13 level.
2. A recommendation by the secondary school last attended regarding fitness for university studies.
3. A complete academic report for the three final years of secondary school.
4. Results of standardized tests offered by the Service for Admission to College and University.

The Grade 13 program should include Mathematics A, Mathematics B, Physics and Chemistry. Superior students who have completed a full Grade 13 but who lack one of the latter three courses will also be eligible.

Candidates seeking admission to the program in Engineering Science should have excellent standing.

3. APPLICATION PROCEDURES

Candidates currently in Ontario Grade 13 should apply through their high school using the General Application Form.

Other candidates should write to the Office of Admissions for a questionnaire which they will be invited to fill out for preliminary consideration.

4. STANDARDIZED TESTS

Candidates from Ontario secondary schools are encouraged to write the standardized tests offered by the Service for Admission to College and University. Candidates from educational jurisdictions outside Ontario may improve their competitive position by taking the aptitude and applicable achievement tests offered by the Service for Admission to College and University or the aptitude test offered by the College Entrance Examination Board. For information they should write to the Service for Admission to College and University, 151 Slater Street, Ottawa, Canada, or to the College Entrance Examination Board, Box 592, Princeton, New Jersey 08540, U.S.A.

5. CANDIDATES OFFERING CERTIFICATES OTHER THAN ONTARIO GRADE 13:

The following certificates are usually accepted as equivalent to Ontario Grade 13 although individual subjects cannot always be equated. Candidates offering Senior Matriculation programs from provinces other than Ontario must offer from their final secondary school year a full program including mathematics, physics and chemistry.

Alberta, Manitoba, Nova Scotia, Saskatchewan — Grade 12
British Columbia, New Brunswick — Grade 13 or First Year University
Newfoundland — First Year Memorial University
Prince Edward Island — First Year course at University of Prince Edward Island.
Quebec — Senior High School Leaving Certificate; English Catholic Senior High School Leaving Certificate (5th Year High—Grade 12). Other certificates as well as C.E.G.E.P. I will be considered.

UNITED STATES, CENTRAL AND SOUTH AMERICA

First Year University standing (normally 30 semester hours) in acceptable subjects from an accredited institution. Students with high school diploma and C.E.E.B. Advanced Placement examinations will be considered.

ENGLAND, WEST INDIES, EAST AND WEST AFRICA, HONG KONG

General Certificate of Education, Higher School Certificate or University of Hong Kong Matriculation Certificate showing either passes in five subjects of which at least two must be passed at advanced (or principal) level; or passes in four subjects of which at least three must be passed at advanced (or principal) level. In either case passes are required in Physics, Chemistry and an acceptable mathematics subject. At least two of these must be at advanced level.

INDIA, PAKISTAN

Bachelor's degree with high standing.

6. ENGLISH FACILITY

Applicants for the University of Toronto who are not Canadian citizens and whose mother tongue is not English may be required to meet an appropriate standard in a recognized test of English facility such as the University of Michigan English Language Test, the Certificate of Proficiency in English issued by the Universities of Cambridge or Michigan, or the Test of English as a Foreign Language (T.O.E.F.L.). The University of Toronto is a sponsoring agency for the University of Michigan English Language Test and information about the test is sent to any applicant of whom it will be required.

7. MATURE STUDENTS

Candidates 24 years of age or older who have lived in Ontario for a minimum period of one year may request special consideration if they have not completed the regular admission requirements in full. In order to be admitted to the Faculty of Applied Science and Engineering all such candidates must have Grade 13 or equivalent preparation in mathematics, physics and chemistry. Interested candidates should consult the Office of Admissions for further information.

8. APPLICATION PROCEDURES

All Candidates must submit an application form and supporting documents to the Office of Admissions, University of Toronto, Toronto 181.

Supporting documents include all final secondary school certificates held. These certificates must indicate the subjects studied and grades obtained. If a certificate is not available at the time of application, candidates must indicate the exact name of the certificate to be presented for admission, and the subjects included therein, as well as the approximate date available. A notarized English translation must accompany certificates which are in a language other than English or French.

In addition a student who has previously attended a University must submit the following:

(*a*) Official transcripts issued by the University or College previously attended, giving in detail the courses completed, with the standing and grades in each. Transcripts or a supporting letter from the Registrar of the University or College must indicate that the candidate has been granted honourable dismissal and is eligible for re-admission to the institution concerned in the session for which he seeks admission to the University of Toronto;

(*b*) Official statements or calendars giving full information on the content of the University courses covered by the transcripts submitted.

For application forms and further information about admission requirements, consult the Office of Admissions, stating in the first letter what credentials will be offered with a listing of subjects and grades obtained.

The closing date for the receipt of applications is June 1. Only in circumstances which the Committee on Admissions deems exceptional will a late application be considered.

9. EARLY ADMISSION

(Ontario Grade 13 students only)

Ontario Grade 13 students with good school records may be offered admission as early as June 11.

Students wishing to be considered for Early Admission should ensure that their applications are forwarded by their schools not later than April 1.

10. CANDIDATES WHO HAVE PREVIOUSLY FAILED IN UNIVERSITY WORK

Candidates with a previous failure in university work may be considered individually on their merits; candidates with two previous failures are normally refused admission.

11. PROCEDURE FOR REGISTRATION

Detailed instructions concerning registration will be mailed to returning and newly admitted students before the beginning of each academic year.

12. HEALTH REQUIREMENTS

Every person admitted to the University as an undergraduate must, at the time of his or her first medical examination by the University Health Service, present satisfactory evidence of successful vaccination within three years prior to the date of the examination, or must be vaccinated by the examining physician.

COLLEGES

With the establishment of New College and Innis College, which are open to students of all faculties, it is now possible for students of the Faculty of Applied Science and Engineering to become members of a college. Membership in a college is not obligatory, and application for membership is at the option of the student.

Students entering the First Year who are interested in becoming members of either college should indicate their choice in the space provided on the University's admission application form. A college fee of $15 is required upon acceptance.

The facilities of Innis College and New College are described below.

INNIS COLLEGE

Innis College was constituted on July 1, 1964, and admitted its first students in the following September. It is a multi-faculty college of the University of Toronto, and includes undergraduate students in all Faculties and Schools of the University.

A special feature is the Writing Laboratory. This service offers assistance to Innis College students in the skills and methods of writing essays and other academic reports. A staff of experienced teachers is available to give individual instruction.

The College has limited residential space available in houses on campus. Separate application for residence accommodation must be made directly to the Residence Co-ordinator of Innis College.

Students entering First Year will be invited to apply for membership after they have been accepted into their Faculty or School. Students entering the Second to Fourth Years who wish to join the College should obtain an application form from the Registrar, Innis College, University of Toronto.

A special college fee of $15 is payable to the Chief Accountant of the University of Toronto. This payment is made after the applicant has received notice of his acceptance by Innis College.

NEW COLLEGE

New College is a multi-faculty co-educational college; in addition to students from the Faculty of Arts and Science those from other Faculties and Schools are eligible for membership. This gives students from all divisions of the University the opportunity to participate in the activities of a college and to associate with students in other fields of study. Tutorial classes are provided for First Year students in some subjects.

The new building, centrally located on the west campus, provides academic, social and dining facilities for all members of the College and in addition accommodates nearly 300 male students in residence.

Students applying for membership in the College who wish accommodation in the Residence must apply on the prescribed form which may be obtained from the Dean of Students, New College.

RESIDENCE ACCOMMODATION

DEVONSHIRE HOUSE

Devonshire House, the University Residence for Men, accepts students from all Faculties. The facilities of the residence include a library, music listening room, music practice room, common rooms, kitchenettes, laundry room, television and games rooms. It does not have a dining hall. Members may take their meals at Hart House, Howard Ferguson Hall, or New College, all located nearby.

Application forms may be obtained from the Secretary to the Dean, Devonshire House, University of Toronto. Application should be made as early as possible.

NEW COLLEGE

The residence facilities of New College, and the procedure for application, are described in the entry under Colleges, above.

OTHER COLLEGES

Each of the four Arts Colleges also maintains a Men's Residence, into which some engineering students may be accepted. Further information may be obtained from University College – Dean of Men; Victoria College – Senior Tutor; Trinity College – Registrar, Trinity College; St. Michael's College – Dean of Men.

HOUSING SERVICE

For the convenience of those students who are not able to find accommodation in the University and College residences, the University Housing Service maintains a listing of rooming houses, flats, apartments and homes. Information may be obtained by telephoning 928-2542.

Off-campus housing of this nature is not subject to University regulation. However every effort is taken to make the information on the accommodation as complete as possible and students are encouraged to assist in this effort by reporting on the quality of the accommodation that they have occupied.

CAMPUS CO-OPERATIVE RESIDENCE INCORPORATED offers residence and apartment accommodation for graduate and undergraduate students. Total occupancy is 300 in residence, half male, half female, and 50 in apartments. Meals are provided, and non-residents are invited to eat at the Co-op Dining Rooms. Since the University of Toronto has no official connection with Campus Co-operative Residence, Inc., inquiries should be addressed direct to Campus Co-operative Residence Incorporated, 395 Huron Street, Toronto 181, Ontario.

MARRIED STUDENT APARTMENTS

Apartment accommodation for married students is provided by the Ontario Student Housing Corporation in buildings located in the Bloor-Yonge area. The apartments (bachelor, one-bedroom and two-bedroom units) are unfurnished except for refrigerators, stoves and window drapes. Tenancy is by lease and is restricted to married couples of whom one or other must be registered as a full-time student at the University of Toronto. Additional information and application forms may be obtained at the University Housing Service, 49 St. George Street.

TARTU COLLEGE

Tartu College, opened in 1969, offers accommodation to undergraduate and post-graduate students in 444 single rooms and 15 double rooms. Cooking facilities are provided for groups of six. The rate for single rooms is $90 per month and $75 per month in double rooms. A rebate of $5 per month is granted to students who stay a full eight months. The college is located on Bloor Street at Madison Avenue. Since the University has no official connection with the college, all enquiries should be addressed to the Reservations Office, Tartu College, 310 Bloor Street West, telephone 925-4747.

ST. ANDREW'S-UNIVERSITY DAY NURSERY

This day nursery, established and supported by the University of Toronto, the Graduate Students' Union and the Students' Administrative Council, provides pre-school education and day care facilities for children of University of Toronto students. Children aged two to five years are accepted.

The nursery, located at St. Andrew's United Church, 117 Bloor Street East, is well equipped and staffed and is licensed under the Day Nursery Act, Province of Ontario. It operates from 8:30 a.m. to 5:45 p.m. throughout the winter and summer academic sessions. Fees are reasonable, and noon meals and morning and afternoon snacks are provided.

Priority of enrolment is given to children of University students, although children of other members of the University community will be considered.

Information may be obtained from the nursery (telephone 921-7078) or from the School of Graduate Studies.

THE UNIVERSITY OF TORONTO CAREER COUNSELLING AND PLACEMENT CENTRE

The Placement Centre, located at 581 Spadina Avenue, is open from 8:45 a.m., to 5 p.m., each week-day. The staff of the Centre maintain lists of part-time, permanent and summer employment opportunities in a wide variety of fields including the various branches of engineering. Engineering undergraduates are invited to drop in to discuss careers and employment problems.

Students looking for summer jobs should register at the Centre early in the academic term. This is important because job priorities are established on the basis of registration dates. Also, to be eligible for assistance under the Ontario Student Aid Plan, it is necessary for a student who has *not* obtained summer employment to have both registered at the Placement Centre and to have sought employment. The Centre will provide students who comply with these regulations with a letter for use with his O.S.A.P. application.

Early registration is also advisable for the fourth year permanent employment interviews which are organized by the Centre each year in the second week in December. Early registrants are given first choice of available interview times.

Students are given an opportunity to explore a variety of careers at a lecture and discussion series on "Careers in Industry, Government, and the Professions", presented by the Centre each year during the month of October. Watch the Varsity and Toike-Oike for specific career topics and dates.

IV

Fees, Deposits and Expenses

FEES

1. Undergraduate students in the Faculty of Applied Science and Engineering must pay annual fees according to the schedule listed below. The total fee in each case is made up of the academic fee and incidental fees; all incidental fees are payable in the first term.

Students will receive by mail in August a fees form and instructions for the payment of fees. In order to avoid delay in registration at the opening of the session it is recommended that at least the first term instalment of fees be forwarded by return mail before the end of August.

Fees may be paid by certified cheque, money order or personal cheque payable to the University of Toronto at par, and mailed to the Office of the Comptroller, University of Toronto, Toronto 181.

2. Payment of at least the First Term instalment must be made before the opening day of the session. An admit-to-lectures card cannot be issued until the student has complied with this requirement.

3. The Second Term instalment of fees, if not already paid, is due on the opening day of the second term and must be paid not later than January 17. After this date a penalty will be imposed. All fees for the session must have been paid in full before the student can be admitted to the annual examinations.

4. Adjustment of fees for students who withdraw is made up to the twenty-fourth week of the session.

5. Fees, residence dues and other charges set forth in this calendar are subject to change by the Board of Governors.

SCHEDULE OF FEES

Men Academic Year	*Academic Fee	†Incidental Fees	Total Fee (if paid in one instalment)	First Term Instalment	Second Term Instalment
I–IV	$650	$69	$719	$471	$260

Women					
I–IV	$650	$41	$691	$443	$260

*The Academic Fee includes the following fees:
Tuition; Library and Laboratory Supply; one Annual Examination; Laboratory Fee; and Degree.

†These Incidental Fees include the following fees:
For men – Hart House; Students' Administrative Council; Athletic; Health Service; Engineering Society; Faculty Athletic Association.
For women – Students' Administrative Council; Athletic; Health Service; Engineering Society.

LATE REGISTRATION FEE

Any student who registers after the last date for normal registration in his or her own faculty or school is required to pay a late registration fee of $10 plus $1 for each day of delay to a maximum of $20.

EQUIVALENT CERTIFICATE FEE

Each student who has been admitted to the First Year upon a certificate or certificates granted outside the Province of Ontario and covering all or any part of the admission requirements, must pay a fee of $5.

ADVANCED STANDING FEE

Each student who has been admitted to advanced standing from another university or college, must pay a fee of $10.

SPECIAL STUDENTS' FEES

The fee is $95 per subject, payable to the Fees Department.

SUMMARY OF STUDENTS' EXPENSES

The following approximate statement of expenses will give the student a general idea of the cost of obtaining an education in the Faculty of Applied Science and Engineering in the University of Toronto, exclusive of personal expenses:

1. Fees, see schedule page 17.	
2. Board and lodging, per week	$25 up
3. Books and instruments, per year	about $150
4. Miscellaneous personal expenses	$250 up

V

Programs and Degrees

UNDERGRADUATE PROGRAMS

The Faculty offers the following programs leading to the degree of Bachelor of Applied Science:

Civil Engineering (Program 1)
Mechanical Engineering (Program 3)
Industrial Engineering (Program 4)
Engineering Science (Program 5)
Chemical Engineering (Program 6)
Electrical Engineering (Program 7)
Metallurgy and Materials Science (Program 8)
Geological Engineering (Program 9)
Aerospace Engineering (offered as an option in Engineering Science. See page 72.)

Except for the First Year, which is also offered on a part-time basis through the Division of University Extension (see below), completion of any of these programs requires full-time attendance at the University. The curricula of the various programs are set out in detail in Section VI. The regulations for standing and promotion are given in Section VII.

FIRST YEAR – DIVISION OF UNIVERSITY EXTENSION

The First Year program (Division A only) is offered through the Division of University Extension for students interested in part-time evening study. Completion of this program qualifies the student for entry into the Second Year of all courses except Engineering Science. As there is no provision in the Division of University Extension for courses beyond the first-year level, students wishing to complete their studies for the degree must enter into full-time study in the regular courses in the Faculty of Applied Science and Engineering.

Information regarding the First Year Extension Program may be obtained from the Degree Courses Section, Division of University Extension, 84 Queen's Park, Toronto 181.

GRADUATE STUDY AND RESEARCH

Facilities are available in the Departments of the Faculty for postgraduate study and research leading to the degrees of Master of Engineering (M.Eng.), Master of Applied Science (M.A.Sc.), and Doctor of Philosophy (Ph.D.). For further information see the Calendar of the School of Graduate Studies.

SPECIAL STUDENTS

Graduates of the University of Toronto and of recognized universities who wish to take one or more undergraduate subjects may be registered as special students in the Faculty of Applied Science and Engineering, subject to the approval of the teaching department concerned. Application must be made to the Secretary of the Faculty.

INTERIM HIGH SCHOOL ASSISTANT'S CERTIFICATE TYPE A

Graduates of engineering programs may be admitted to Type A certificate courses at the College of Education, University of Toronto, if they submit official transcripts which indicate that they have sufficient academic credits.

Graduates of engineering programs who lack sufficient academic credits for admission to Type A courses at the College of Education may be eligible for admission to the Type B course and later for endorsement of the Type B certificate.

Inquiries regarding admission to the Type B course should be addressed to the Registrar, the College of Education, University of Toronto. Inquiries regarding endorsement of Type B certificates or admission to Type A certificate courses should be addressed to the Director, Committee on Advanced Standing, the College of Education, University of Toronto.

ASSOCIATIONS OF PROFESSIONAL ENGINEERS

Graduation from the Faculty of Applied Science and Engineering leads to registration as a Professional Engineer in the various Associations of Professional Engineers throughout Canada.

VI Curriculum

The curriculum for 1971–72 reflects the introduction of a term system in which all courses of instruction (with the exception of certain courses taken in the Faculty of Arts and Science) will be one term in duration. There are two terms in the annual session, each concluding with final examinations in the courses offered. With the exception of the First Year, for which there are special provisions, students will be evaluated for promotion at the end of each term.

The curriculum provides a good deal of latitude to the student in choosing his program of study, and it is possible, within limits, for a student to proceed at a pace slower or faster than the normal rate. A regular program consists of a maximum of six courses† per term with a total weight of 48 units; with the approval of the Chairman of his Department a student enrolled in the second or higher years may elect to reduce his load to a minimum of 40 units per term, or to increase it to a maximum of 60 units. First-year students may not take less than the normal load of 48 units per term.

On the following pages of this section the curriculum of each program is set forth in detail. As a guide to students in apportioning their time a weight factor is shown opposite each course of instruction. The weight factor represents the number of hours per week, including both scheduled class-room time and home work, that the average student is expected to devote to that course. This weight factor is also used in the computation of the student's weighted average in the work of the year.

The program and regulations regarding the courses of study and examination, contained in this Calendar, hold good for this academic year only, and the Faculty of Applied Science and Engineering does not bind itself to adhere for the whole period of a student's course to the conditions here laid down.

ELECTIVE COURSES

Elective courses fall into three categories, viz. Technical Electives; Non-Technical Electives (in First and Second Year programs); and Open Electives (in Third and

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†In the session 1971–72 some programs specify seven courses per term as a transitional step in the development of the new curriculum.

Fourth Year programs). The following paragraphs provide instructions on the selection of elective courses:

1. TECHNICAL ELECTIVES: These are specified in the prescription for the program in which the student is registered. In most cases the choice is restricted to a specified list of available technical electives. The availability of a particular elective course may depend on a sufficient number of students wishing to take it; in a few courses it may be necessary to limit the number of students enrolled.

2. NON-TECHNICAL ELECTIVES (First and Second Years): Each student in the First and Second Year must include in his program a Non-Technical Elective in each term. In general, acceptable non-technical electives have as their central theme the study of man as an individual or of man as a social being.

The student may select his Non-Technical Elective from either of the following groups of courses:

(a) *"In-House" Non-Technical Electives*

The following courses have been arranged specifically for students of the Faculty of Applied Science and Engineering, and have been scheduled in slots MW1 and TR12, so as to be available to all students. (For descriptions of these courses, see page 148.)

ECO 281	Economics
ENG 281F/S	Effective Writing
ENG 282F/S	Twentieth Century Literature
ENG 283F/S	Canadian Literature
ENG 284F/S	Varieties of Fiction
ENG 285F/S	Drama and Modern Theatre
ENG 286F/S	Literature and Science
HPS 280F/S	History of Science and Technology
HPS 281F	History of Technology and Engineering up to the Industrial Revolution
HPS 282S	History of Technology and Engineering from the Industrial Revolution to the Present
HPS 283S	Technology, Engineering and Society
PHL 291F	Science and Society
PHL 292S	Science and Philosophy

(b) *Courses in the Faculty of Arts and Science*

Students desiring a broader choice in their non-technical electives may select courses from the following list of courses in the Faculty of Arts and Science (with the exceptions as noted). Students making this selection should bear in mind that these courses are somewhat more demanding, in general, than the "In-House" courses.

Acceptable Arts and Science Courses (with exceptions as noted below). Courses listed in the calendar of the Faculty of Arts and Science under the following prefixes:

ANT
CIN
EAS
ECO
ENG
FAR
FRE
FSC
FSE
FSL
FSM
FSR
FST
FSW
FSY
GER
GLL
GRH
GRK
HIS
HPS
ISL
ITA
JAH
JAL
JAP
JAZ
JER
JMC
LAT
LIN
MUS
NES
PHI
PHL
POL
PRT
PSY
REL
SLA
SOC
SPA

Note: (i) Courses coded 195 may not be taken for credit
(ii) A half-course given over two terms has a code letter Y, e.g. ITA 221Y
(iii) Students wishing to take courses at the 300 level and higher must obtain the approval of the teaching department offering the course.

List of Exceptions (courses bearing the above prefixes which are not acceptable as Non-Technical Electives)

ECO 222	Computing for Social and Management Sciences
ECO 240F	Mathematical Approach to Macroeconomic Theory
ECO 241S	Mathematical Approach to Microeconomic Theory
ECO 343	Introduction to Mathematical Economics
MUS 343Y	Acoustics
PHL 250F	Modern Symbolic Logic
PHL 250S	Modern Symbolic Logic
PHL 251S	Probability and Inductive Logic
PHL 313F	Games, Decisions and Social Choice
PHL 350S	Intermediate Logic Probability
PHL 353S	Set Theory
POL 206	Quantitative Methods for Political Science
PSY 209F	Physiological Psychology
PSY 315S	Introduction to Mathematical Psychology
PSY 319F	Physiology of Sensory Motor Behaviour
PSY 322	Physiological Psychology Laboratory
PSY 329S	Computer Applications to Psychology
SOC 201	Statistics and Research Methods
SOC 318	Advanced Research Methods

3. OPEN ELECTIVES (Third and Fourth Years only): In each term of the Third and Fourth Years there is provision for an "open elective" which the student must fill. Courses acceptable as open electives are (i) any course which is acceptable as a Non-Technical Elective as defined in section 2 above, or (ii) any degree credit course listed in a University of Toronto Calendar, other than those offered by the Faculty of Applied Science and Engineering. In the latter case the student must obtain the approval of the teaching department offering the course.

First Year Studies

Chairman For First Year Studies:

P. E. Burke, B.E. (N.S. TECH.), M.A.SC.

Coordinating Staff:

V. C. Hamacher, B.A.SC.(WATERLOO), M.SC.(QUEEN'S), PH.D.(SYR.) Department of Electrical Engineering
W. Janischewskyi, M.A.SC., Department of Electrical Engineering
W. A. Miller, PH.D.(MCG.), Department of Metallurgy and Materials Science.
R. A. Ross, M.A., PH.D. Department of Mathematics
S. Sandler, M.A.SC. Department of Chemical Engineering
G. D. Scott, M.A., PH.D., Department of Physics
S. D. Scott, B.SC., M.SC., PH.D. Department of Geology
I. W. Smith, M.A.SC. Department of Mechanical Engineering
G. T. Will, M.A.SC. Department of Civil Engineering
C. A. Wrenshall, B.E. (SASK.) Department of Civil Engineering

FIRST YEAR STUDIES

The First Year program is designed to build a strong foundation in the basic disciplines which underlie the whole field of engineering. There are two first year curricula – Division A, the standard curriculum and Division B, the enriched curriculum for students intending to pursue the Engineering Science program. Admission to the Division B curriculum is granted only to students with better-than-average ability in mathematics and the sciences. Students undertaking this curriculum must maintain satisfactory term and year averages in their first year work in order to pursue the Engineering Science program in their second year. (See page 40.)

Students entering Division A must elect one of the following programs in which they expect to continue in second year – Civil Engineering, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Electrical Engineering, Metallurgy &

Materials Science, and Geological Engineering. Subject to the availability of places, a student who successfully completes the First Year in Division A may request to transfer to any other program within that Division.

Students wishing to transfer to a different program at the end of first year should make application to the Secretary of the Faculty not later than July 15.

FIRST YEAR CURRICULUM — DIVISION A

Civil Engineering	Electrical Engineering
Mechanical Engineering	Metallurgy and Materials Science
Industrial Engineering	Geological Engineering
Chemical Engineering	

		Lect.	*Lab. & Tutorial*	*Wt.*
Term 1F				
Computer Programming†	APS100F/S	1	3	6
Applied Mechanics	CIV100F	3	2	10
Engineering Graphics†	CIV135F/S	2	5	8
Chemistry	CHE100F	3	3	12
Mathematics I	MAT180F	4	3	12
Non-Technical Elective*				8
Term 1S				
Computer Programming†	APS100F/S	1	3	6
Engineering Graphics†	CIV135F/S	2	5	8
Electricity and Magnetism	ELE121S	3	2	10
Mathematics II	MAT181S	3	4	12
Non-Technical Elective*				8
△ **and one of:**				
Engineering Design	APS101S	3	1½	10
Chemical Engineering	CHE101S	3	1½	10
Applied Physical Geology	GLG180S	3	1½	10
Structure and Properties of Matter	MMS100S	3	1½	10

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†One half of the students in Division A will take Computer Programming in Term 1F; the other half will take Engineering Graphics. The arrangement is reversed in Term 1S.

*Students will select one course each term from the list of Non-Technical Electives on Page 22 of the Calendar, or from a list of courses available in the Faculty of Arts and Science.

△None of these technical electives shall be pre-requisite for any course given in a subsequent term.

FIRST YEAR CURRICULUM — DIVISION B

Engineering Science

			Lab. &	
Term 1F		*Lect.*	*Tutorial*	*Wt.*
Mechanics (Statics)	CIV101F	2	1	6
Chemistry	CHE102F	3	3	10
Computer Programming	CSC180F	1	3	5
Calculus I	MAT194F	3	2	11
Elements of Physics I	PHY180F	2	2½	9
*Non-Technical Elective				7
Term 1S				
Electricity	ELE150S	3	—	8
Linear Algebra	MAT185S	2	1	8
Calculus II	MAT195S	2	1	8
Elements of Physics II	PHY181S	2	2½	9
*Non-Technical Elective				7
△**and one of:**				
Engineering Design	APS101S	3	1½	8
Chemical Engineering	CHE101S	3	1½	8
Engineering Graphics	CIV136S	2	2½	8
Applied Physical Geology	GLG180S	3	1½	8
Structure and Properties of Matter	MMS100S	3	1½	8

*Students will select one course each term from the list of Non-Technical Electives on Page 22 of the Calendar, or from a list of courses available in the Faculty of Arts and Science.

△None of these technical electives shall be pre-requisite for any course given in a subsequent term.

Civil Engineering

Professor and Chairman of the Department:
T. C. Kenney, B.ENG.(MC.G.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.)

Associate Professors and Assistant Chairmen of the Department:
K. A. Selby, B.A.SC., M.B.A., PH.D.(ILL.)
P. M. Wright, B.E.(SASK.), M.SC., PH.D.(COL.)

Professors:
F. A. DeLory, B.ENG.(MC.G.), M.A.SC., D.I.C.(IMP.), PH.D.(LOND.)
C. Hershfield, B.SC., C.E.(MAN.), M.A.SC.
M. W. Huggins, B.A.SC., M.A.SC.
P. H. Jones, B.A.SC., M.S.(NORTHWEST.), PH.D.(NORTHWEST.)
R. H. Mills, B.SC.(WITWATERSRAND) (on leave for the session)
H. R. Rice, B.SC.(QU.)
J. Schwaighofer, DIP. ING.(GRAZ.), M.S.(PENN. ST.), PH.D.(PENN. ST.), DR. TECH.(GRAZ.)
R. M. Soberman, B.SC.(DALH.), PH.D.(M.I.T.)

Associate Professors:
J. D. Barber, B.A.SC., M.A.SC.
A. P. Bernhart, DIP. ING.(GRAZ.), DR.TECH.(GRAZ.)
J. R. Brown, B.SC., M.B., PH.D., D.SC.(LOND.), M.D.(LOND.)
R. A. Collins, B.A.SC., M.S.(ILL.), PH.D.(ILL.)
A. C. Davidson, B.SC., C.E., B.SC., E.E.(MAN.), M.A.SC.
M. M. Davis, B.SC.(QU.), M.SC.(PURDUE)
H. R. Frizzle, B.SC., E.E.(N.S.TECH)
J. Ganczarzyk, M.SC., D.SC.(GLIWICE), D.SC.(WARSAW)
B. J. Haynes, B.A.SC.
G. W. Heinke, B.A.SC., M.A.SC., PH.D.(MCM.)
H. L. Macklin, B.A.SC.
E. I. Robinsky, B.A.(BEIRUT), B.SC.(BEIRUT), M.S.(HARVARD), PH.D.
J. Timusk, B.A.SC., M.A.SC., PH.D.(LOND.)

S. M. Uzumeri, B.A.SC., M.A.SC.
J. Vlcek, B.SC.F.(N.B.), M.A.SC., D.SC.(BRATISLAVA) (*on leave for the session*)
C. A. Wrenshall, B.E.(SASK.)

Assistant Professors:
S. J. G. Bird, B.A.SC., M.A.SC.
M. P. Collins, B.E.(CANTERBURY), PH.D.(N.S.W.)
R. C. Gunn, B.A.SC., M.A.SC.
K. Meipoom, B.A.SC., M.A.SC.
V. R. Riley, B.A.SC., PH.D.(CANTAB.)
G. K. Rodgers, B.A.SC., M.A.SC.(U.B.C.), PH.D.
G. N. Steuart, B.SC.(SASK.), M.SC.(CALIF.), PH.D.
A. K. F. Turner, B.SC.(QU.), M.A.(COLOMBIA), PH.D.(PURDUE)
G. T. Will, B.A.SC., M.A.SC.

Lecturers:
V. P. Borecky, DIP. ING.(PRAGUE), M.A.
E. Karuks, B.A.SC., M.A.SC.
R. G. Rice, B.A.SC., M.SC.(M.I.T.)

Special Lecturers:
A. C. R. Albery, B.A. (CANTAB.)
R. G. Foster, M.A.SC.
W. R. McDougall, B.A.SC.
K. A. Reichert, B.SC., M.A.SC.(WATERLOO)
D. E. Thomson, B.A.SC., M.SC.(ILL.)

CIVIL ENGINEERING

Program 1

Civil Engineering as a profession is concerned with improving man's environment through the planning, designing and construction of facilities such as dams, buildings, transportation systems and municipal services. Needless to say, these activities encompass a very wide range of knowledge and this in turn creates special curriculum problems.

The program in Civil Engineering is arranged so that a student may undertake either a relatively broad study of the discipline or a more comprehensive examination of one of its principal fields (structural, municipal and sanitary, transportation, geotechnical, and surveying). This flexibility is derived from the fact that a fourth year student's program consists mainly of elective courses and a thesis. The departmental electives are timetabled so as to maximize the freedom of students to take the electives of their choice.

A second recent change in the program is in the introduction of several project-oriented courses in the second year program. These were established to provide students with an excellent understanding of the engineering approach to planning and design.

In summary, the program is designed to develop well-informed creative engineers possessing innovative and directive capabilities.

SECOND YEAR CIVIL ENGINEERING

			Lab. &	
Term 2F		*Lect.*	*Tutorial*	*Wt.*
Strength of Materials	CIV 210F	3	—	8
Surveying	CIV 255F	3	3	9
Computer Programming	CIV 260F	2	2	8
The Engineer and his Environment	CIV 267F	2	4	8
Calculus	MAT 280F	3	2	9
Non-technical Elective				6
Term 2S				
Engineering Materials	CIV 209S	4	3	10
Mechanics and Design of Structures	CIV 211S	4	2	10
Environmental Systems	CIV 240S	2	—	6
The Civil Engineer and his Profession	CIV 268S	2	4	8
Geology	GLG 280S	3	1½	8
Non-technical Elective				6
Practical Experience	APS 299	—	—	—

THIRD YEAR CIVIL ENGINEERING

			Lab. &	
Term 3F		*Lect.*	*Tutorial*	*Wt.*
Design of Structures II	CIV 312F	3	2	10
Soil Mechanics	CIV 321F	2	1	6
Survey Camp*	CIV 358F	—	—	—
Engineering Mathematics	CIV 370F	3	2	9
Probability and Statistics	CIV 371F	2	2	7
Fluid Mechanics	MEC 351F	3	3	10
Open Elective				6

THIRD YEAR CIVIL ENGINEERING (CONTINUED)

Term 3S		*Lect.*	*Lab. & Tutorial*	*Wt.*
Design and Structures III	CIV 313S	3	2	10
Foundations	CIV 322S	2	2	7
Transportation Systems	CIV 330S	3	2	9
Municipal Engineering	CIV 340S	2	2	7
Technical Elective**		3	2	9
Open Elective				6

*Survey Camp is taken prior to the commencement of regular courses in Third Year and the results included with those for the subsequent term on the basis of a weighting of 8 units.

**See list of Technical Electives on Page 31.

FOURTH YEAR CIVIL ENGINEERING

Term 4F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Administration and Management	CIV 475F	2	—	6
Technical Elective**		3	2	9
Technical Elective		3	2	9
Technical Elective		3	2	9
Technical Elective		3	2	9
Open Elective				6
Term 4S				
Public Speaking	CIV 474S	—	2	3
Thesis	CIV 499S	—	6	12
Technical Elective		3	2	9
Technical Elective		3	2	9
Technical Elective		3	2	9
Open Elective				6

***Technical Electives.* During Third and Fourth Year, students select eight technical selectives. Each student is advised to consult with a member of the staff in establishing the electives in his program.

The technical electives offered by the Department of Civil Engineering are given below.

Fall Term Electives

CIV 405F	Advanced Strength of Materials
CIV 416F	Reinforced Concrete I
CIV 419F	Interminate Structures
CIV 421F	Foundations and Earthwork
CIV 429F	Air Photo Interpretation
CIV 430F	Traffic Engineering
CIV 431F	Transportation Planning
CIV 440F	Pollution Control Engineering
CIV 450F	Water Resources and Hydrology
CIV 455F	Photogrammetry and Remote Sensing
CIV 479F	Special Studies in Civil Engineering
CIV 498F	Thesis†

†With the permission of the Chairman of the Department, a student may elect to undertake a 21-unit thesis by taking both CIV 498F and CIV 499S.

Spring Term Electives

APS 420S	*Urban and Regional Planning
CIV 375S	*Engineering Economics
CIV 414S	*Advanced Engineering Materials
CIV 417S	Reinforced Concrete II (Pre-requisite: CIV 416F)
CIV 418S	Behaviour and Design of Steel Structures
CIV 420S	Construction Engineering
CIV 422S	*Engineering Geology
CIV 432S	Highway Engineering
CIV 456S	*Engineering Applications of Surveying
CIV 457S	Geodetic Control Surveys
CIV 479S	Special Studies in Civil Engineering
MEC 452S	Hydraulic Engineering

*Available to Third and Fourth Year students.

With the approval of the Chairman of the Department, a student may include as part of his elective program, courses that are offered outside the Department provided that the University Department, Faculty or Institute offering the course has agreed to accept him for those courses.

Mechanical Engineering

STAFF OF THE DEPARTMENT

Professor and Chairman of the Department:
W. D. Baines, B.SC.(ALTA.), M.S., PH.D.(IOWA)

Associate Professor and Associate Chairman
D. S. Scott, B.SC.(QUEEN'S), M.SC.(QUEEN'S), PH.D.(NORTHWESTERN)

Professors:
F. C. Hooper, B.A.SC., D.I.C.(LOND.)
L. E. Jones, B.SC.(C.E.) (MAN.), M.A.SC., PH.D.
H. J. Leutheusser, DIP. ING.(KARLSRUHE), M.A.SC., PH.D.
F. P. J. Rimrott, DIP. ING.(KARLSRUHE), M.A.SC., PH.D.(PENN. STATE), DR. ING.(DARMSTADT)
I. W. Smith, M.A.SC.

Associate Professors:
A. H. Abdelmessih, B.M.E.(CAIRO), M.S.(OKLAHOMA STATE), PH.D.
A. B. Allan, M.A.SC.
I. G. Currie, B.SC.(STRATHCLYDE), M.A.SC.(B.C.), PH.D.(CAL.I.T.)
R. C. Fenton, DIP. ING.(BUD.), PH.D.(N.S.W.)
D. F. James, B.SC.(QUEEN'S), M.S.(CAL. TECH.), PH.D.(CAL. TECH.)
J. F. Keffer, M.A.SC., PH.D.
V. Klemes, DIP. ING.(BRNO), C.SC.(BRATISLAVA)
B. Tabarrok, B.SC.(WOLVER. & STAFF.), D.PHIL.(OXON)
J. VandeVegte, DIP. ING.(DELFT), M.A.SC., PH.D.
C. A. Ward, B.SC.(TEX.), PH.D.(NORTHWEST.)

Assistant Professors:
D. L. Allen, B.SC.(DAL.), B.E.(N.S. TECH.), M.A.SC., PH.D.
J. S. Ansari, B.E.(OSMANIA), M.S.(PURDUE), PH.D.(PURDUE)
R. C. Flanagan, B.SC.(N.B.), PH.D.(B.C.)
G. E. Godfrey, M.A.SC.

D. McCammond, B.SC.(QU. BELFAST), PH.D.(QU. BELFAST)
P. S. Shen, B.SC.(LOND.), M.SC.(BIRMINGHAM), PH.D.(LOND.)

MECHANICAL ENGINEERING

Program 3

Traditionally associated with the art and science of power generation and the machines and devices by which power is usefully applied and controlled, Mechanical Engineering, like other branches of the engineering profession, participates actively in the advancement of knowledge and interprets this knowledge in the design and development of practical systems.

In manufacturing industry, in the transportation and power utilities, in the high-performance field of air and space engineering, or in engineering aspects of major works and structures, the mechanical engineer finds professional occupation, either as employee or consultant. His responsibility will generally be for the superintendence of operations and personnel, for the design of products and processes, and may include the administration of enterprises.

The curriculum in Mechanical Engineering provides an analytical training in mathematics and the physical sciences designed as a disciplinary basis for active professional practice. Recognition is given, however, to the purer scientific and philosophical concepts essential to postgraduate study and research.

For the First Year curriculum see Division A, page 25.

SECOND YEAR MECHANICAL ENGINEERING

Term 2F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Engineering Law	APS 300F	1	—	2
Circuit Theory and Measurements	ELE 270F	3	3	11
Calculus	MAT 293F	2	2	8
Mechanics of Deformable Bodies I	MEC 211F	3	3	10
Differential Equations	MEC 261F	3	3	11
Non-technical Elective				6
Term 2S				
Electromechanical Energy Conversion	ELE 272S	3	3	9
Dynamics I	MEC 201S	3	1½	9
Mechanics of Deformable Bodies II	MEC 212S	3	1½	8
Materials Science	MMS 223S	3	3	8
Probability and Statistics	STA 282S	2	2	8
Non-technical Elective				6

THIRD YEAR MECHANICAL ENGINEERING

Term 3F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Electronics	ELE 370F	2	3	9
Vibrations	MEC 303F	3	3	11
Thermodynamics	MEC 321F	3	3	11
Engineering Analysis I	MEC 362F	3	3	11
Open Elective				6
Term 3S				
Electromechanical Energy Conversion	ELE 371S	2	3	8
Fluid Mechanics I	MEC 341S	3	3	10
Engineering Analysis II	MEC 363S	3	1	8
Heat Engineering	MEC 395S	2	3	8
Engineering Design	MEC 397S	2	3	8
Open Elective				6

FOURTH YEAR MECHANICAL ENGINEERING

Term 4F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Engineering Law	APS 300F	1	—	2
Numerical Analysis	APM 481F	2	2	8
Control Systems	MEC 455F	3	3	11
Thesis	MEC 499	—	3	11
Open Elective				6
and one of:				
Thermal Power Generation	MEC 424F	3	1½	10
Engineering Analysis III	MEC 464F	3	1½	10
Manufacturing Science	MEC 475F	3	1½	10
Term 4S				
Heat and Mass Transfer	MEC 431S	3	3	10
Applied Fluid Mechanics	MEC 443S	3	3	10
Applied Elasticity	MEC 495S	3	1½	9
Thesis	MEC 499	—	3	3
Open Elective				6
and one of:				
Dynamics II	MEC 302S	3	1½	10
Fluid Mechanics II	MEC 342S	3	1½	10
Microscopic Thermodynamics	MEC 425S	3	1½	10
Science of Design	MEC 473S	3	1½	10

Industrial Engineering

STAFF OF THE DEPARTMENT

Professor and Chairman of the Department:
B. Bernholtz, M.A.,PH.D.(CAL. TECH.)

Associate Professor and Assistant Department Chairman:
R. W. P. Anderson, M.A.SC.

Professors:
J. W. Abrams, A.B.(CALIF.), PH.D.(CALIF.)
P. J. Foley, M.A.(GLASGOW)
A. Kruger, B.A., PH.D.(M.I.T.)
A. Porter, M.SC.(MANCH.), PH.D.(MANCH.), F.R.S.C. (*on leave for the session*)

Associate Professors:
J. Abrham, M.A.(CHARLES), PH.D.(CHARLES)
S. H. Cohn, M.A.
T. A. Lambe, B.A.SC.(U.B.C.), M.SC.(STAN.), PH.D.(STAN.)
J. G. C. Templeton, B.A., A.M.(PRINC.), PH.D.(PRINC.)

Assistant Professors:
P. E. Bonzon, B.A.(LAUS.), M.SC.(LAUS.), PH.D.(LAUS.)
J. A. Buzacott, B.SC.(SYDNEY), B.E.(SYDNEY), M.SC.(BIRMINGHAM), PH.D.(BIRMINGHAM)
A. A. Cunningham, M.A.(OXFORD), PH.D.(ADELAIDE)
M. J. M. Posner, B.A.SC., PH.D.
I. B. Turksen, B.S.(PITTS.), M.S.(PITTS.), PH.D.(PITTS.)
E. L. Vitalis, B.B.A.(MINN.), M.A.(MINN.)

Lecture (part-time)
E. E. Pickett, B.A.SC., M.A.

Special Lecturers (part-time):
J. M. Tusiewicz, B.SC.(ENG.)(LOND.), M.A.SC., M.B.A.
J. Vanderheyden, B.A.SC.
Mrs. J. L. Vitalis, B.A.(MINN.)

INDUSTRIAL ENGINEERING

Program 4

The modern view of Industrial Engineering is that of a field concerned with the analysis, design improvement and operation of integrated systems of men, materials and equipment. This concept crystallized when it became clear that certain modern technical fields, including operational research, control theory, computer science, probability and statistics, systems theory and human factors engineering, constituted a body of knowledge particularly useful in the operation and management of modern business, industry and government.

As a logical outcome of this development, the course in Industrial Engineering was established in 1958 to provide graduates in engineering specializing in the theory and practice of these subjects. This specialization rests upon a substantial foundation in science and mathematics, in fundamental engineering disciplines including fluid mechanics, applied thermodynamics, electric science, mechanics of materials, materials science and automation, and in such subjects as economics, organizational structure, financial control and the behavioural sciences.

The curriculum in Industrial Engineering allows, but does not require, each student to take a Technical Elective outside the Department in each term in each of Second, Third and Fourth Year. For students entering First Year in 1971–72 or later, one of the six possible technical electives must be used for a Basic Science subject chosen from a list to be issued by the Faculty.

Students choosing to take technical electives are urged to select them with care, in order to improve their general engineering education or their knowledge of an area in which they wish to specialize. A list of areas of concentration and corresponding recommended subjects is distributed to students in Industrial Engineering to assist them in their choice of technical electives.

In addition to subject IND 401F, Industrial Engineering Seminar, the staff and students of the Department conduct a seminar series in the spring term. This series is similar in character to IND 401F, and is intended primarily but not exclusively for Third Year students. Although attendance is not required and no academic credit is given, this seminar is considered an important part of each student's engineering education.

For the First Year curriculum see Division A, page 25.

SECOND YEAR INDUSTRIAL ENGINEERING

			Lab. &	
Term 2F		*Lect.*	*Tutorial*	*Wt.*
Elements of Industrial Engineering I	IND 200F	2	1	7
Computers and Programming I	IND 202F	2	2	9
Calculus	MAT 293F	2	2	8
Probability	STA 291F	2	2	9
Non-technical Elective				6
and one of:				
Materials Science	MMS 222F	3	3	9
Technical Elective*				9
Term 2S				
Elements of Industrial Engineering II	IND 201S	2	1	7
Calculus and Differential Equations	MAT 294S	2	2	8
Statistics	STA 292S	2	2	9
Non-technical Elective				6
and two of:				
Mechanics of Materials	CIV 205S	2	3	9
Electrical Engineering	ELE 271S	3	3	9
Technical Elective*				9

**Technical Electives* are courses which satisfy at least one of the following criteria:

1. Any technical course listed in the 1971–72 calendar of the Faculty of Applied Science and Engineering.
2. Any course in the Natural Sciences and Mathematics in the Faculty of Arts and Science.
3. Any course listed as part of one of the Department's recommended programs.

In each case, the Department reserves the right to disallow courses which involve excessive duplication of material. In particular, subjects required for all students in any year of the Industrial Engineering program may not be chosen as Technical Electives.

THIRD YEAR INDUSTRIAL ENGINEERING

Term 3F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Numerical Analysis	APM 381F	2	2	8
Accounting I	COM 390F	2	1	8
Operational Research I	IND 301F	2	2	9
Computers and Programming II	IND 303F	2	2	9
Open Elective				6
and one of:				
Differential Equations	APM 391F	2	2	8
Industrial Relations**	IND 304F	2	1	8
Technical Elective*				8
Term 3S				
Operational Research II	IND 302S	2	2	9
Control Engineering	MEC 357S	2	2	8
Probability and Statistics	STA 392S	2	2	9
Open Elective				6
and two of:				
Numerical Analysis II	APM 386S	2	2	8
Accounting II	COM 391S	2	1	8
Fluid Mechanics and Thermodynamics	MEC 348S	2	3	8
Technical Elective*				8

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*See Page 37 for note on Technical Electives.

**This course may not be combined with ECO 344 in any program and it can only be combined with ECO 339F/340S with the approval of the Department of Political Economy.

FOURTH YEAR INDUSTRIAL ENGINEERING

Term 4F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Industrial Engineering Seminar	IND 401F	2	—	2
Open Elective				6
and five of:				
State Space Methods in Process Control	IND 407F	2	1½	8
Man as a Machine	IND 409F	2	—	8
Man as an Individual	IND 411F	2	—	8
Fundamentals of Management Science	IND 413F	2	1½	8
Production Systems	IND 415F	2	1½	8
Stochastic Models	IND 417F	2	1½	8
System Simulation	IND 418F	2	1½	8
Term Thesis**	IND 497F	—	3	8
Thesis*	IND 498F	—	3	8
Technical Elective				8
Term 4S				
Engineering Law	APS 300S	1	—	2
Open Elective				6
and five of:				
Optimal Control of Processes	IND 408S	2	1½	8
Man as an Information Processor	IND 410S	2	—	8
Organizational Behaviour	IND 412S	2	—	8
Applications of Management Science	IND 414S	2	1½	8
Advanced Industrial Engineering	IND 416S	2	1½	8
Information and Optimization	IND 419S	2	1½	8
Mathematical Programming	IND 420S	2	1½	8
Management Information Systems	IND 421S	2	1½	8
Term Thesis**	IND 497S	—	3	8
Thesis*	IND 499S	—	3	8
Technical Elective				8

*If IND 498F is selected, then IND 499S must be taken also.

**If IND 498F is not selected, then either IND 497F or IND 497S must be selected, but not both of them.

Engineering Science

FACULTY MEMBERS OF THE DIVISION

Chairman of the Division:

B. Etkin, M.A.SC., D.ENG., F.R.S.C., F.C.A.S.I. (Professor of Aerospace Engineering)

Associate Chairman of the Division:

I. H. Rowe, M.A.SC., D.I.C.(IMP. COLL.), PH.D.(LOND.), (Associate Professor of Electrical Engineering)

Members of the Division:

R. L. Armstrong, M.A., PH.D.(Professor of Physics)
K. T. Aust, M.A.SC., PH.D. (Professor of Metallurgy and Materials Science)
G. F. D. Duff, M.A., PH.D., F.R.S.C. (Professor and Chairman of the Department of Mathematics)
J. N. P. Hume, M.A., PH.D. (Professor of Physics and Computer Science)
I. H. Spinner, M.A.SC., PH.D. (Professor of Chemical Engineering)
J. VandeVegte, DIP. ING.(DELFT), M.A.SC., PH.D. (Associate Professor of Mechanical Engineering)

ENGINEERING SCIENCE

Program 5

The Engineering Science program is designed for students whose primary interest is in the applications of science to modern technology, and who wish to prepare themselves for careers in research, development or teaching. The undergraduate course provides excellent preparation for post-graduate work in a wide range of specialities in Engineering, Science and Mathematics, and the majority of graduates from this course do proceed to graduate study. Students who graduate from the course and do not continue their studies are nevertheless well qualified to fill a variety of positions in industry, government and teaching.

The courses offered are of a high standard, so that only students with better-than-average ability in, and aptitude for, mathematics and science can expect to succeed in them. For this reason, admission is granted only to those who have achieved high standing in their previous academic work, and continuation in the program requires a minimum of 55% at the end of the first term and 66% at the end of the second (see page 151). Transfers into Division A can normally be made without difficulty up to the end of the second year. Thereafter, each case is considered on its merits.

The curricula for the first two years of the course are common for all students, with some technical electives available in terms 1S and 2S. There are available eight carefully planned *options*,† each of which provides a specialized preparation for a particular branch of applied science. In addition students have the opportunity not to enroll in any one of these options, but to take an *elective program*, as outlined below.

For the First Year curriculum see Division B, page 26.

SECOND YEAR ENGINEERING SCIENCE

			Lab. &	
Term 2F		*Lect.*	*Tutorial*	*Wt.*
Numerical Methods	APM 281F	2	1	7
Chemical Systems	CHE 209F	3	3	9
Electric Circuits	ELE 250F	3	3	9
Calculus III	MAT 295F	3	1	8
Physics III (Fields and Waves)	PHY 280F	3	2½	9
Non-technical Elective				6
Term 2S				
Complex Variables	MAT 289S	3	1	9
Physics IV (Quantum Physics)	PHY 281S	2	2½	8
Probability and Statistics	STA 287S	3	1	9
two of:				
Engineering Design*	APS 201S	—	6	8
Mechanics of Materials	CIV 203S	2	3	8
Computer Languages	CSC 280S	2	—	8
Non-technical Elective				6

†For further information about the Aerospace Option, see page 71.

*This course will be limited to 20 students.

Each student will be asked to indicate before the end of Second Year his intended course of study in Third Year. This information is for Faculty planning only, and is not binding on the student.

Students may elect

(a) to enrol in one of the 8 options listed, in which case up to three elective substitutions of subjects are permitted, or

(b) to select a program that does not conform to any one of the options.

In case (a), substitutions must be on a basis of roughly equal weights, so that the modified program has approximately the same weight as the standard option. In case (b) the weight shall average approximately 48 units for the two terms. In both cases, the selection of electives is subject to the constraints imposed by the current timetable, and by prerequisites. Electives may be chosen from among the subjects offered to other options in Engineering Science; from among the subjects listed in this Calendar that are offered in programs other than Engineering Science; or, with the approval of the offering department, from subjects offered in other Faculties.

IN ALL CASES, ELECTIVE CHOICES (other than those explicitly provided for within options) MUST BE APPROVED BY A MEMBER OF THE DIVISION STAFF.

THIRD YEAR ENGINEERING SCIENCE

Option 5A, Aerospace

Term 3F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Mechanics	AER 301F	3	—	8
Mechanics of Structures	AER 302F	3	—	9
Aerospace Laboratory I	AER 303F	—	3	6
Technical Elective				9
Open Elective				6
Term 3S				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Aerospace Laboratory II	AER 304S	—	3	6
Fluid Mechanics	AER 305S	3	—	9
Technical Elective				8
Open Elective				6

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Option 5C, Chemical

Term 3F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Mass Transfer Operations	CHE 312F	2	2	9
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Thermodynamics and Kinetics I	CHE 303F	2	3	9
Chemical Engineering Problems and Lab I	CHE 315F	—	2	7
Technical Elective				7
Open Elective				6

Term 3S				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Thermodynamics and Kinetics II	CHE 304S	2	3	9
Mass Transfer Operations II	CHE 313S	2	1½	8
Chemical Engineering Problems and Lab II	CHE 316S	—	2	7
Molecular Engineering	CHE 317S	3	—	8
Open Elective				6

Option 5CS, Computer Science

Term 3F				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Physical Electronics I	ELE 350F	2	1½	7½
Introductory Electronics	ELE 351F	2	1½	7½
Computer Organization	ELE 353F	3	2½	10
Switching Theory	ELE 405F	2	1	7
Open Elective				6

Term 3S				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Operational Research	IND 331S	2	2	7
Electronic Circuits I	ELE 354S	3	1½	8
System Software I	CSC 380S	2	6	10
Theory of Computation	CSC 390S	2	—	7
Open Elective				6

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Option 5E, Electrical

		Lect.	Lab. & Tutorial	Wt.
Term 3F				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Physical Electronics I	ELE 350F	2	1½	7
Introductory Electronics	ELE 351F	2	1½	7
System and Signal Analysis I	ELE 355F	3	1	9
Electromagnetic Fields	ELE 357F	2	2½	8
Open Elective				6
Term 3S				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Physical Electronics II	ELE 352S	2	1½	7
Electronic Circuits I	ELE 354S	3	3	11
System and Signal Analysis II	ELE 356S	2	2½	8
and one of:				
Electromechanical Systems	ELE 371S	2	3	7
Statistical Physics	PHY 381S	2	—	6
Technical Elective				7
Open Elective				6

Option 5G, Geophysics

		Lect.	Lab. & Tutorial	Wt.
Term 3F				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Principles of Geology	GLG 120F	2	3	9
Geophysics	PHY 225F	2	1	6
two of:				
Mechanics	AER 301F	3	—	8
Introductory Electronics	ELE 351F	2	1½	8
System and Signal Analysis I	ELE 355F	3	1	9
Open Elective				6
Term 3S				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	*Lab. & Tutorial*	*Wt.*
Principles of Geology	GLG 122S	2	3	9
Physics of Solids and Fluids	PHY 224S	2	—	6
Solid State Physics	PHY 304S	2	3	9
One of:				
System and Signal Analysis II	ELE 356S	2	2½	8
Statistical Physics	PHY 381X	2	1½	9
Open Elective				6
Option 5M, Materials Science				
Term 3F				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Physical Metallurgy	MMS 303F	3	3	10
Metallurgical Thermodynamics	MMS 306F	3	4	12
Technical Elective				8
Open Elective				6
Term 3S				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Physics of Metals	MMS 304S	3	3	9
Materials Science	MMS 307S	3	—	8
Technical Elective				12
Open Elective				6
Option 5NT, Nuclear & Thermal Power				
Term 3F				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Mechanics	AER 301F	3	—	8
Fluid Mechanics	MEC 354F	3	3	12
Quantum Physics	PHY 380F	3	3	12
Open Elective				6
Term 3S				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	Lab. & Tutorial	Wt.
Experimental Stress Analysis	MEC 315S	3	—	8
Statistical Thermodynamics	MEC 326S	3	—	9
Heat Engineering	MEC 327S	2	3	8
Technical Elective				7
Open Elective				6
Option 5P, Physics				
Term 3F				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Mechanics	AER 301F	3	—	8
Quantum Physics	PHY 380F	3	3	12
one of:				
Physical Electronics I	ELE 350F	2	1½	7
Introductory Electronics	ELE 351F	2	1½	7
Electromagnetic Fields	ELE 357F	2	2½	8
one of:				
Nuclear and Particle Physics	PHY 305F	2	—	5
Molecular Biophysics	PHY 309F	2	—	5
Open Elective				6
Term 3S				
Theory of Functions	MAT 389	2	—	5
Differential Equations	MAT 395	2	—	5
Statistical Physics	PHY 381X	2	3	12
one of:				
Physical Electronics II	ELE 352S	2	1½	7
Experimental Stress Analysis	MEC 315S	3	—	8
two of:				
Physics of Solids and Fluids	PHY 224S	2	—	6
Solid State Physics	PHY 304S	2	—	6
Applied Nuclear Physics (prereq. PHY 305F)	PHY 307S	2	—	6
Cellular Biophysics	PHY 310S	2	—	6
Open Elective				6

FOURTH YEAR ENGINEERING SCIENCE

Option 5A, Aerospace

		Lect.	Lab. & Tutorial	Wt.
Term 4F				
Thesis	APS 495	—	—	6
Differential Equations	APM 441	2	—	6
Open Elective				6
*and a selection of courses from Groups A and B totalling approximately 30 units:				
Group A				
Aerodynamics	AER 401F	3	—	9
Space Flight Dynamics	AER 402F	2	—	6
Advanced Mechanics of Structures	AER 403F	2	—	6
Group B				
Physics and Mechanics of Solids	AER 404F	3	—	9
Plasmadynamics	AER 405F	3	—	9
Engineering Design I	AER 406F	—	3	8
Aerospace Laboratory III	AER 408F	—	6	8
Term 4S				
Thesis	APS 495	—	—	6
Differential Equations	APM 441	2	—	6
Open Elective				6
*and a selection of courses from Groups A and B totalling approximately 30 units:				
Group A				
Gasdynamics	AER 410S	3	—	9
Stability and Control of Aircraft	AER 411S	2	—	6
Aerolasticity	AER 412S	2	—	6
Group B				
Physics of Radiating Gases	AER 413S	3	—	9
Transport Phenomena	AER 414S	2	—	6
Control Systems	MEC 458S	3	3	11
Engineering Design II	AER 407S	—	3	8
Aerospace Laboratory IV	AER 409S	—	6	8

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*In the aggregate of terms 4F and 4S the student's program must include at least two courses from Group A. Courses in Groups A and B for which there is insufficient demand may be withdrawn.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Option 5C, Chemical

Term 4F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Thesis	APS 496	—	—	5
Differential Equations	APM 441	2	—	6
Rate Processes I	CHE 435F	3	—	8
Technical Elective				7
Open Elective				6
and two of:				
Chemical Plant Design	CHE 406F	—	6	8
Strategy of Product and Process Development	CHE 409F	2	3	8
Optimal Control of Chemical Systems	CHE 437F	3	1½	8
Chemical Engineering Project	CHE 441F	—	6	8
Term 4S				
Thesis	APS 496	—	—	5
Differential Equations	APM 441	2	—	6
Rate Processes II	CHE 436S	3	—	8
Technical Elective				7
Open Elective				6
and two of:				
Thermodynamics of Chemical Systems	CHE 438S	3	—	8
Selected Topics in Organic Chemistry	CHE 439S	3	—	8
Modelling and Simulation of Chemical Systems	CHE 440S	3	—	8

Option 5CS, Computer Science

Term 4F				
Differential Equations	APM 441	2	—	6
System Software II	CSC 480F	2	6	10
System and Signal Analysis I	ELE 355F	3	1	9
Communication Principles I	ELE 453F	2	1	7
Techniques of Optimization	ELE 455F	3	2	10
Open Elective				6

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Term 4S		*Lect.*	*Lab. & Tutorial*	*Wt.*
Thesis	APS 497S	—	—	9
Differential Equations	APM 441	2	—	6
Computation Methods for Partial Differential Equations	APM 486S	2	1	7
Automata Theory	CSC 448S	2	1	7
Operating Systems	CSC 468S	2	1	7
Switching Circuits	ELE 432S	2	1½	7
Open Elective				6
Option 5E, Electrical				
Term 4F				
Differential Equations	APM 441	2	—	6
Open Elective				6
*__five of:__				
Switching Theory	ELE 405F	2	1	7
Network Theory	ELE 412F	2	1	7
Semiconductor Physics (prereq. PHY 381E)	ELE 435F	2	1½	7
Computer Programming & Data Structures	ELE 440F	2	1	7
Control Systems I (prereq. ELE 355F)	ELE 450F	2	1½	7
Electronic Circuits II	ELE 452F	2	3	8
Communication Principles I	ELE 453F	2	1	7
Microwave Systems	ELE 456F	2	1½	7
Term 4S				
Thesis	APS 498S	—	—	8
Differential Equations	APM 441	2	—	6
Open Elective				6
*__four of:__				
Introduction to Nuclear Engineering	CHE 430S	2	—	6
Switching Circuits	ELE 432S	2	1½	7
Quantum Electronics (prereq. PHY 380F)	ELE 437S	2	1	7

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*Courses for which there is insufficient demand may be withdrawn.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	*Lab. & Tutorial*	*Wt.*
Computer Organization & Programming	ELE 441S	2	1	7
Biomedical Engineering (limited enrolment)	ELE 445S	2	1½	7
Introduction to Optimal Control (prereq. ELE 450F)	ELE 451S	2	—	7
Communication Principles II (prereq. ELE 453F)	ELE 454S	2	3	8
Microwave Electronics (prereq. ELE 456F)	ELE 457S	2	1½	7
Operations Research	IND 331S	2	2	7
Integrated Circuits (prereq. ELE 452F)	ELE 431S	2	1½	7

Option 5G, Geophysics

Term 4F				
Thesis	APS 499	—	—	3
Differential Equations	APM 441	2	—	6
Systems and Signal Analysis I	ELE 355F	3	1	9
Physics of the Earth	PHY 412	2	—	6
Geophysical Methods	PHY 413X	2	6	12
Open Elective				6
one of:				
Classical Physics of Continua	PHY 411	2	—	6
Atmospheric Physics	PHY 414	2	—	6
Term 4S				
Thesis	APS 499	—	—	10
Differential Equations	APM 441	2	—	6
Physics of the Earth	PHY 412	2	—	6
Geophysical Methods	PHY 413X	2	6	14
Open Elective				6
one of:				
Classical Physics of Continua	PHY 411	2	—	6
Atmospheric Physics	PHY 414	2	—	6

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Option 5M, Materials Science

Term 4F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Thesis	APS 479	—	—	9
Differential Equations	APM 441	2	—	6
Physics of Metals	MMS 402F	3	4	10
Theory of Metallurgical Reactions	MMS 410F	2	2	8
Technical Elective				8
Open Elective				6
Term 4S				
Thesis	APS 479	—	—	10
Differential Equations	APM 441	2	—	6
Materials Science	MMS 408S	3	3	10
High Temparature Physical Chemistry	MMS 409S	2	2	8
Technical Elective				8
Open Elective				6

Option 5NT, Nuclear and Thermal Power

Term 4F				
Thesis	APS 478	—	—	6
Differential Equations	APM 441	2	—	6
Nuclear Engineering	CHE 442F	3	3	11
Thermal Energy Conversion I	MEC 428F	3	3	11
Nuclear Physics I	PHY 403C	2	—	8
Open Elective				6
Term 4S				
Thesis	APS 478	—	—	8
Differential Equations	APM 441	2	—	6
Thermal Energy Conversion II	MEC 429S	3	3	11
Heat Transfer	MEC 433S	2	—	6
Control Systems	MEC 458S	3	3	11
Open Elective				6

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Option 5P, Physics

Term 4F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Thesis	APS 496	—	—	5
Differential Equations	APM 441	2	—	6
Technical Elective				7
Open Elective				6
three of:				
Thermodynamics	PHY 303F	2	—	8
Quantum Theory	PHY 400	2	—	8
Statistical Mechanics I	PHY 401C	2	—	8
Nuclear Physics I	PHY 403C	2	—	8
Solid State Physics I	PHY 405C	2	—	8
Interaction of Radiation with Matter	PHY 406F	2	—	8
Group Theory and Molecular Physics	PHY 408F	2	—	8
Relative Theory	PHY 410	2	—	8
Quantum Physics Laboratory I	PHY 427F	—	5	8
Term 4S				
Thesis	APS 496	—	—	5
Differential Equations	APM 441	2	—	6
Technical Elective				7
Open Elective				6
three of:				
Quantum Theory	PHY 400	2	—	8
*Statistical Mechanics II	PHY 401D	2	—	8
*Nuclear Physics II	PHY 403D	2	—	8
High Energy Physics	PHY 404S	2	—	8
*Solid State Physics II	PHY 405D	2	—	8
Magnetic Resonance	PHY 407S	2	—	8
Quantum Optics	PHY 409S	2	—	8
Relativity Theory	PHY 410	2	—	8
Quantum Physics Laboratory II	PHY 428S	—	5	8

*The corresponding fall term course is a prerequisite.

Chemical Engineering and Applied Chemistry

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Z. May, DIP. ING. CHEM.(WARSAW)
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A. Rozeiu, DIP. CHEM. ENG.(BUCHAREST)
R. B. Thompson, B.A.SC.

Special Lecturer:
C. P. Brockett, B.SC.(M.I.T.)

CHEMICAL ENGINEERING

Program 6

The chemical engineer is concerned with the development and operation of processes by means of which matter is chemically altered to a more useful form, and in the design, construction, operation and management of plant in which to effect such changes. In addition to such obviously chemical processes as those encountered in the petroleum refining and petro-chemical industry, a great variety of industrial processes involve chemistry and require the abilities of the chemical engineer. In order to equip a student to start his professional career as a chemical engineer, the undergraduate course is intended to provide him with training in the principles of the major divisions of chemistry and chemical engineering, together with the essentials of other engineering subjects.

In the final year, certain elective subjects and the topic chosen for the thesis allow the student to specialize according to his interests and abilities. The thesis serves as an introduction to research, and its nature may vary widely depending on the interests of the staff and students. It may, for example, be concerned with an experimental laboratory investigation, the design of a process, or a computer study of a chemical system.

For the First Year curriculum see Division A, page 25.

SECOND YEAR CHEMICAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Physical Chemistry I	CHE 201F	2	—	—	5
Analytical Chemistry Laboratory*	CHE 203F				
Analytical Chemistry	CHE 204F	2	12	—	14
Industrial Process Operations I	CHE 205F	3	—	2	9
Inorganic Chemistry I	CHE 217F	2	—	—	5
Calculus	MAT 280F	3	—	2	9
Non-technical Elective					6
Term 2S					
Physical Chemistry II	CHE 202S	2	3	—	8
Industrial Process Operations II	CHE 206S	3	6	2	13
Organic Chemistry	CHE 207S	3	3	—	10
Applied Math in Chemical Engineering	CHE 208S	2	—	1	6
Inorganic Chemistry II	CHE 218S	2	—	—	5
Non-technical Elective					6
Practical Experience	APS 299				

*A voluntary pre-session course offered by the Senior Staff in Chemical Engineering prior to the commencement of regular courses in Second Year.

THIRD YEAR CHEMICAL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thermodynamics and Kinetics I	CHE 301F	3	6	2	14
Applied Mathematics in Chemical Engineering	CHE 305F	2	—	—	6
Organic Chemistry II	CHE 309F	3	9	—	14
Mass Transfer Operations I	CHE 310F	2	—	2	8
Open Elective					6
Term 3S					
Thermodynamics and Kinetics II	CHE 302S	3	6	2	15
Mass Transfer Operations II	CHE 311S	2	4½	1	11
Fluid Mechanics	CHE 314S	3	1½	1	10
one of:					
Fundamental Process Modelling and Simulation	CHE 306S	2	—	1	6
Organic Chemistry of High Polymers	CHE 307S	2	—	1	6
Chemical Engineering Economics	CHE 308S	2	—	1	6
Open Elective					6

FOURTH YEAR CHEMICAL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Chemical Engineering Laboratory	CHE 401F	—	—	9	12
Thesis and Public Dissertation	CHE 499	—	2	—	2
Open Elective					6
one of:					
Chemical Engineering Thermodynamics	CHE 402F	2	—	1	7
Interface Kinetics	CHE 403F	2	—	1	7
Molecular Thermodynamics	CHE 404F	2	—	1	7
one of:					
Chemical Plant Design	CHE 405F	—	—	6	7
Process Modelling and Simulation	CHE 407F	2	—	3	7
Strategy of Product and Process Development	CHE 408F	2	3	—	7
one of:					
Advanced Separation Processes	CHE 410F	2	—	1½	7
Convective Heat & Momentum Transfer	CHE 411F	2	—	1½	7
Pipeline Transportation	CHE 412F	2	—	1½	7
one of:					
Composite Materials	CHE 413F	2	—	1	7
Polymer Engineering	CHE 415F	2	—	1	7
Wood Chemistry	CHE 417F	2	—	1	7
Term 4S					
three of:					
Applied Nuclear Chemistry	CHE 418S	2	—	1	7
Ceramics	CHE 420S	2	—	1	7
Co-ordination Chemistry	CHE 422S	2	—	1	7
Environmental Engineering	CHE 423S	2	—	1	7
Instrumentation Methods	CHE 425S	2	—	1	7
Chemical Bonding	CHE 426S	2	—	1	7
Introduction to Nuclear Engineering	CHE 427S	2	—	1	7
Optimal Control	HE 431S	2	—	1	7
Chemical Reactors	CHE 432S	2	—	1	7
Interfacial Phenomena and Disperse Systems	CHE 433S	2	—	1	7
Chemistry of Organic Compounds	CHE 434S	2	—	1	7
Technical Elective		2	—	1	7
Thesis and Public Dissertation	CHE 499	—	18	2	21
Open Elective					6

Electrical Engineering

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D. J. Shepley, M.D., B.A.SC.

ELECTRICAL ENGINEERING

Program 7

Electrical Engineers are concerned with all things electrical; but such a simple statement fails to convey any real notion of the great variety of activity in which they are engaged, the many aspects of their concern, or the nature of the education that they require.

Electrical engineers are, of course, still involved in the application of new knowledge to the basic areas — the generation, transmission and utilization of electrical power and the communication of information — but they are being faced daily with situations not envisaged even a few years ago. They are searching continuously for new approaches that may be better suited to future needs, as for example, magneto-hydrodynamic generation, microelectronics and satellite communication. There is a growing demand for sophisticated electrical sensing and control equipment for a wide variety of non-electrical processes, and for electronic computers capable of the rapid processing of large volumes of information and the solving of increasingly complex problems.

Within any of these areas the electrical engineer may be engaged in research, development, design, manufacture, operation or management. He may have to assist other engineers and scientists in widely differing fields by supplying them with techniques or insights unfamiliar to them, as for example, in the developing field of bio-medical engineering, or he may have to coordinate the application of many technologies in a single project. In addition to all of this, he must accept considerable responsibility in community affairs.

It is obvious then, from the wide range of his possible involvement, that the electrical engineer needs a professional education of great breadth and depth. In the undergraduate course, stress is laid on building a solid foundation. The time limitation requires that only material which is essential can be included; much that might be immediately helpful must be omitted to make room for that which will still be relevant for several years. On this base, the graduate will have to build his continuing education.

The electrical engineer makes extensive use of mathematical techniques and concepts; mathematics is thus of the utmost importance and a large portion of the course is devoted to it. Fundamental subjects such as mechanics, electrical physics, chemistry and thermodynamics get considerable attention in the early years. The basic electrical engineering subjects (electromagnetic field theory, electronics, machine principles and circuit theory) follow these, with expansion and some specialization in the final year. Also included are a few non-technical subjects of importance. In the final year, only one-third of the curriculum is prescribed by the department; students freely select the rest of their curriculum from a wide range of elective subjects.

Electrical engineering is characterized by the relatively large proportion of its graduates who proceed to post-graduate study to get advanced training in a particular area. Information on this may be obtained from the calendar and other publications of the School of Graduate Studies.

For the First Year curriculum see Division A, page 25.

SECOND YEAR ELECTRICAL ENGINEERING

Term 2F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Calculus	MAT 290F	4	2	11
Circuit Theory I	ELE 210F	3	2	9
Electrical Laboratory	ELE 230F	—	3	4½
Dynamics	MEC 205F	3	2	9
Materials Science I	MMS 221F	3	1½	8½
Non-technical Elective				6

SECOND YEAR ELECTRICAL ENGINEERING (CONTINUED)

		Lect.	Lab. & Tutorial	Wt.
Term 2S				
Numerical Methods	ELE 201S	2	2	7
Circuit Theory II	ELE 211S	2	2	7
Electric and Magnetic Fields	ELE 221S	3	2	9½
Introductory Electronics	ELE 231S	2	3	9½
Thermodynamics and Statistical Mechanics	ELE 235S	3	1	9
Non-technical Elective				6

THIRD YEAR ELECTRICAL ENGINEERING

Term 3F		Lect.	Lab. & Tutorial	Wt.
Applied Mathematics I	ELE 300F	3	2	9½
System and Signal Analysis I	ELE 310F	3	1	9
Electromechanical Energy Conversion I	ELE 312F	2	2½	8
Fields and Waves	ELE 320F	2	2½	8
Physical Electronics I	ELE 335F	2	1½	7½
Open Elective				6
Term 3S				
Applied Mathematics II	ELE 301S	2	2	6
System and Signal Analysis II	ELE 311S	2	2½	7½
Electromechanical Energy Conversion II	ELE 313S	2	2½	7½
Electronic Circuits I	ELE 331S	2	3	8
Physical Electronics II	ELE 336S	2	1½	6½
Materials Science II	MMS 322S	2	1½	6½
Open Elective				6

FOURTH YEAR ELECTRICAL ENGINEERING

Term 4F		Lect.	Lab. & Tutorial	Wt.
Control Systems I	ELE 410F	3	1½	9
Electronic Circuits II	ELE 430F	2	3	8
Thesis	ELE 499	—	—	4
Open Elective				6

FOURTH YEAR ELECTRICAL ENGINEERING (CONTINUED)

		Lect.	Lab. & Tutorial	Wt.
three of:				
Applied Mathematics III	ELE 400F	2	1	7
Switching Theory	ELE 405F	2	1	7
Network Theory	ELE 412F	2	1	7
Electromagnetic Theory	ELE 420F	2	1	7
Semiconductor Physics	ELE 435F	2	1½	7
Computer Programming and Data Structures	ELE 440F	2	1	7
*{ Power System Analysis	ELE 413F	2	1½	7
{ Quantum Physics	ELE 436F	2	1½	7
Other Technical Elective		2	1½	7
Term 4S				
Thesis	ELE 499	—	—	7
Open Elective				6
five of:				
Introduction to Nuclear Engineering	CHE 429S	2	1½	7
Control Systems II	ELE 411S	2	1½	7
Communication Systems	ELE 416S	2	3	7
Switching Circuits	ELE 432S	2	1½	7
Computer Organization and Programming (Prereq. ELE 440F)	ELE 441S	2	1	7
Biomedical Engineering	ELE 445S	2	1½	7
Acoustics	ELE 446S	2	1½	7
{ Power System Control	ELE 414S	2	1½	7
{ Radiation and Propagation (Prerequisite ELE 420F)	ELE 421S	2	1½	7
{ Integrated Circuits	ELE 431S	2	1½	7
{ Electromechanical Energy Conversion III	ELE 419S	2	1½	7
{ Illumination	ELE 447S	2	1½	7
{ Quantum Electronics (Prerequisite ELE 436F)	ELE 437S	2	1	7
{ Microwave Electronics (Prerequisite ELE 420F)	ELE 457S	2	1½	7
{ Power Semiconductor Circuits	ELE 433S	2	1½	7
Other Technical Elective		2	1½	7

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*Bracketed courses can not be taken together.

Metallurgy and Materials Science

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METALLURGY AND MATERIALS SCIENCE

Program 8

"Metallurgy and Materials Science" is the study of the production, structure, and properties of the engineering materials used in structures, machines and devices.

Modern technology makes increasingly severe demands upon both metallic and non-metallic solids; in fact, it is difficult to think of an engineering project, the basic limitations of which do not reside in the materials which are available. For example, aerospace travel requires materials capable of withstanding extremes of heat, cold and pressure; the utilization of nuclear energy is limited only by materials which can withstand the effects of radiation; the transistor and the computer depend upon materials having special electrical and magnetic properties. As industry expands, the metallurgist or materials engineer is being called upon to play an increasingly important role in the economy.

The course is designed to place primary emphasis upon the fundamental principles which underlie the chemical, physical and mechanical properties of solids. In the fourth year, each student is assigned an experimental problem involving original work and, where possible, this is related to the actual research in progress in the department. The student is, therefore, introduced to the methods of research.

The department is equipped with modern facilities for the study of the structure and properties of materials. This equipment includes x-ray diffraction units, an electron beam microprobe analyzer, an electron microscope, several optical metallographs, materials preparation and testing equipment, facilities for the production and measurement of high temperatures, high vacuum equipment, etc.

For the First Year curriculum see Division A, page 25.

SECOND YEAR METALLURGY AND MATERIALS SCIENCE

Term 2F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Introduction to Modern Physics	PHY 282F	3	1	7
Mechanics of Materials	CIV 204F	3	1½	9
Calculus	MAT 293F	2	2	8
Structure of Materials and Metallography	MMS 201F	2	3	9
Physical Chemistry I	MMS 202F	2	3	9
Non-technical Elective				6
Term 2S				
Calculus and Differential Equations	MAT 294S	2	2	8
Probability and Statistics	STA 282S	2	2	8
Physical Chemistry II	MMS 203S	2	3	8
Metallurgical Chemistry	MMS 204S	2	5	10
Materials Science	MMS 205S	4	—	8
Practical Experience	APS 299	—	—	—
Non-technical Elective				6

THIRD YEAR METALLURGY AND MATERIALS SCIENCE

			Lab. &	
Term 3F		*Lect.*	*Tutorial*	*Wt.*
Differential Equations	APM 391F	2	2	8
Mineral Processing	MMS 301F	2	3	8
Thermodynamics	MMS 302F	2	4	10
Physical Metallurgy	MMS 303F	3	3	10
Open Elective				6
*one Materials Science elective:				
Polymer Engineering	CHE 415F	2	1	7
Physical Electronics I	ELE 335F	2	1½	7½
Physical Electronics I	ELE 350F	2	1½	7½
Materials Science Laboratory	MMS 331F	—	3	6
Term 3S				
Numerical Analysis	APM 236S	2	2	8
Transport Phenomena	MEC 349S	3	3	9
Physics of Metals	MMS 304S	3	3	9
Extractive Metallurgy	MMS 305S	4	3	10
Open Elective				6
*one of:				
Applied Nuclear Chemistry	CHE 418S	2	1	7
Introduction to Nuclear Engineering	CHE 427S	2	1	7
Extractive Metallurgy Project	MMS 332S	—	3	6

*With the approval of the Chairman of the Department, any other suitable course may be substituted as an elective.

FOURTH YEAR METALLURGY AND MATERIALS SCIENCE

			Lab. &	
Term 4F		*Lect.*	*Tutorial*	*Wt.*
Electrical Systems	ELE 470F	2	3	9
Extractive Metallurgy	MMS 401F	2	4	9
Physics of Metals	MMS 402F	3	4	10
Thesis	MMS 499	—	6	8
Open Elective				6
***one of**:				
Composite Materials	CHE 413F	2	1	7
Operational Research I	IND 431F	2	2	8
Powder Metallurgy	MMS 431F	2	—	6
Term 4S				
Materials Science	MMS 403S	3	1	8
Electrochemical Processes	MMS 404S	2	2	8
Thesis	MMS 499	—	12	13
Open Elective				6
one Chemical Metallurgy elective:				
Advanced Chemical Metallurgy	MMS 406S	1	3	7
Metallurgical Systems Analysis	MMS 407S	2	1	7
***one of**:				
Ceramics	CHE 420S	2	1	7
Operational Research II	IND 432S	2	2	8
Physical Metallurgy Project	MMS 432S	—	3	6

*With the approval of the Chairman of the Department, any other suitable course may be substituted as an elective.

Geological Engineering

The course in Geological Engineering is an interfaculty course, the specialized core of which is provided by the Department of Geology (Faculty of Arts and Science) with assistance from several departments of the Faculty of Applied Science and Engineering. It is administered by a Course Committee the current members of which are:

E. W. Nuffield, B.A.(B.C.), PH.D., F.R.S.C., *Chairman; Professor and Chairman, Department of Geology.*
C. B. Alcock, B.SC., PH.D., A.R.C.S., D.SC.(LOND.), F.R.I.C., M.I.M.M., *Professor and Chairman, Department of Metallurgy and Materials Science.*
W. D. Baines, B.SC.(ALTA.), M.SC., PH.D.(IOWA), *Professor and Chairman, Department of Mechanical Engineering.*
J. G. Breckenridge, B.A.SC., PH.D.(CANTAB), *Professor of Chemical Engineering.*
J. B. Currie, B.A.(MCM.), M.A., PH.D., *Professor of Geology.*
T. C. Kenney, B.ENG.(MCG.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.), *Professor and Chairman, Department of Civil Engineering.*
H. R. Rice, B.SC.(QUEEN'S), *Professor of Mining Engineering.*

GEOLOGICAL ENGINEERING

Program 9

Geology is the science of the earth. It includes, in a large sense, all knowledge of the earth – its origin, history, structure, composition and mineral wealth – and the physical, chemical and biological processes that change the earth. It spans a wide range of sciences and requires a thorough grounding in mathematics and the basic science and engineering disciplines to aid in a proper understanding of the subject and its many applications. Beginning in the fall of 1971, students entering the Second Year of the Program in Geological Engineering will be offered a broad curriculum from which they can choose one of the following three options:

Option A, Mineral Exploration, provides a thorough grounding in basic geology including mineralogy, structure, petrology and stratigraphy. In addition it includes courses in Exploration Geochemistry and Geophysics, and in Mineral Deposits, Petroleum Geology and Geohydrology. Students can round out their education with courses in Mining or courses dealing with the properties of soils.

Option B, Mineral Engineering, which is concerned with the concentration and processing of the valuable contents of the products of mining operations, emphasizes mineralogy in addition to basic physics and chemistry. Students will undertake specialized courses in the subject in the last two years of the Program.

Option C, Engineering Geology, represents the area relating Geology to Civil Engineering, Resource Engineering and Regional Planning. To start with, students take a number of courses in basic geology and engineering. They then can choose from a wide range of courses which qualify them to identify and evaluate the "geological hazards" affecting the design and safety of specific engineering projects and to review regional planning proposals to reduce the destruction of our natural resources and the deterioration of our environment.

The outline of courses listed below shows the complete programs of the three options for only the Second Year. The Third and Fourth Year curricula have still to be planned in detail. It may be assumed, however, that the programs which will be proposed for the Third and Fourth Years of Option A will be basically the same as the Third and Fourth Year programs given below.

For the First Year curriculum see Division A, page 25.

SECOND YEAR GEOLOGICAL ENGINEERING

Option A (Mineral Exploration)

			Lab. &	
Term 2F		*Lect.*	*Tutorial*	*Wt.*
Inorganic Chemistry I	CHE 214F	2	—	7
Principles of Physical Geology	GLG 120F	2	3	9
Mineralogy	GLG 220	2	4	10
Calculus	MAT 293F	2	2	8
Basic Classical and Modern Physics	PHY 283F	3	—	8
Non-technical Elective				6
Term 2S				
Inorganic Chemistry II	CHE 215S	2	—	8
Principles of Historical Geology	GLG 122S	2	3	9
Mineralogy	GLG 220	2	4	10
Basic Electromagnetism	PHY 284S	1	3	7
Non-technical Elective				6

SECOND YEAR GEOLOGICAL ENGINEERING (CONTINUED)

one of:				
Geological Data Processing by Computer	GLG 221S	1	3	8
Calculus and Differential Equations	MAT 294S	2	2	8
Probability and Statistics	STA 282S	2	2	8
Practical Experience	APS 299	—	—	—

Option B (Mineral Engineering)

Term 2F		*Lect.*	*Lab. & Tutorial*	*Wt.*
Principles of Physical Geology	GLG 120F	2	3	9
Mineralogy	GLG 220	2	4	10
Calculus	MAT 293F	2	2	8
Physics and Chemistry of Materials	MMS 225F	4	3	8
Introduction to Modern Physics	PHY 282F	3	1	7
Non-technical Elective				6
Term 2S				
Principles of Historical Geology	GLG 122S	2	3	9
Mineralogy	GLG 220	2	4	10
Physical Chemistry	MMS 203S	2	3	9
Introductory Metallurgy	MMS 224S	2	—	6
Inorganic Chemistry	MMS 226S	2	2	8
Practical Experience	APS 299	—	—	—
Non-technical Elective				6

Option C (Engineering Geology)

Term 2F				
Strength of Materials	CIV 210F	3	—	8
The Engineer and his Environment	CIV 267F	2	4	8
Principles of Physical Geology	GLG 120F	2	3	9
Mineralogy	GLG 220	2	4	10
Calculus	MAT 293F	2	2	8
Non-technical Elective				6
Term 2S				
Engineering Materials	CIV 209S	4	3	10
Environmental Systems	CIV 240S	2	—	6
Principles of Historical Geology	GLG 122S	2	3	9
Mineralogy	GLG 220	2	4	10
Practical Experience	APS 299	—	—	—
Non-technical Elective				6
one of:				
Calculus and Differential Equations	MAT 294S	2	2	8
Probability and Statistics	STA 282S	2	3	8

THIRD YEAR GEOLOGICAL ENGINEERING

			Lab. &	
Term 3F		*Lect.*	*Tutorial*	*Wt.*
*Survey Camp (optional)	CIV 359F	—	—	—
Petrology	GLG 320	2	3	9
Stratigraphy and Sedimentation	GLG 321F	2	2	9
Tectonics	GLG 322	1	3	9
Physical Geochemistry	GLG 324	3	—	9
Open Elective				6
one of:				
Mining Technology	CIV 328F	3	—	6
Airphoto Interpretation	CIV 429F	3	2	9
Physics of the Earth	PHY 412	2	—	6
Term 3S				
Petrology	GLG 320	2	3	9
Tectonics	GLG 322	1	3	9
Physical Geochemistry	GLG 324	3	—	9
Geology of the Canadian Shield	GLG 327S	2	2	9
Open Elective				6
one of:				
Calculus and Differential Equations	MAT 294S	2	2	9
Extractive Metallurgy	MMS 321S	3	—	6
Probability and Statistics	STA 282S	2	3	8

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*Survey Camp is offered prior to the commencement of regular courses in Third Year. The results will be included with those for the subsequent term on the basis of a weighting of 6 units.

**One of these Second Term courses can be taken if PHY was not selected in the First Term.

FOURTH YEAR GEOLOGICAL ENGINEERING

			Lab. &	
Term 4F		*Lect.*	*Tutorial*	*Wt.*
Mineral Deposits	GLG 421	2	3	9
Exploration Geochemistry	GLG 422	2	3	9
Petroleum Geology	GLG 428F	2	3	9
Exploration Geophysics	PHY 308X	2	3	9
Open Elective				6
one of:				
Mine Operation and Administration I	CIV 426F	2	3	6
Soil Mechanics	CIV 321F	2	1	6
Term 4S				
Mineral Deposits	GLG 421	2	3	9
Exploration Geochemistry	GLG 422	2	3	9
Exploration Geophysics	PHY 308X	2	3	9
Thesis	GLG 499S	—	3	9
Open Elective				6
one of:				
Geohydrology	GLG 429S	2	3	6
Foundations	CIV 322S	2	2	7
Mine Operation and Administration II (prerequisite CIV 426F)	CIV 427S	2	3	6

Aerospace Studies

TEACHING STAFF OF THE INSTITUTE FOR AEROSPACE STUDIES

Professor and Director of the Institute:

G. N. Patterson, B.SC.(ALTA.), M.A., PH.D., LL.D., D.SC., F.R.AE.S., F.C.A.S.I., F.A.I.A.A., F.R.S.C., F.A.A.A.S.

Professors and Assistant Directors:

J. H. deLeeuw, DIP. ING.(DELFT), M.S. in A.E.(GEORGIA TECH.), PH.D., F.C.A.S.I. (*Assistant Director – Research.*)

I. I. Glass, B.A.SC., M.A.SC., PH.D., F.A.P.S., F.A.A.A.S., F.C.A.S.I. (*Assistant Director – Education*).

Professors:

B. Etkin, B.A.SC., M.A.SC., D.ENG., F.C.A.S.I., F.R.S.C.

J. B. French, B.A.SC., M.SC.(BIRMINGHAM), PH.D.

H. S. Ribner, B.S.(CAL. TECH.), M.S.(WASH.), PH.D.(WASH.), F.A.P.S., F.A.S.A., F.C.A.S.I.

Associate Professors:

P. C. Hughes, B.A.SC., M.A.SC., PH.D.

G. W. Johnston, B.A.SC., M.A.SC., PH.D.

G. K. Korbacher, DIP. ING.(BERLIN), PH.D.(BRAUNSCHWEIG)

R. M. Measures, B.SC., A.R.C.S., D.I.C., PH.D.(LOND.)

P. A. Sullivan, B.E., M.E.(N.S.W.), D.I.C., PH.D.(LOND.)

R. C. Tennyson, B.A.SC., M.A.SC., PH.D.

S. J. Townsend, B.A.(SASK.), M.A.(SASK.), PH.D.

Assistant Professors:

J. W. Locke, B.A.SC., M.A.SC.

L. D. Reid, B.A.SC., M.A.SC.

AEROSPACE STUDIES

The University of Toronto offers a broad and coherent program of studies in the aerospace sciences and engineering. It is designed to prepare its graduates for work in a variety of areas including civil air transportation, design and development of new aircraft, spacecraft and air cushion vehicles, and fundamental research in many of the relevant underlying areas of science. Future Canadian needs for air and surface transportation, satellite communications, and survey satellites are significant factors in determining the content of the courses and the research projects undertaken.

The courses of study available comprise a basic 4 year program leading to the B.A.Sc. degree, an additional year leading to the M.Eng. or M.A.Sc. degree, and a subsequent Doctoral program. The undergraduate (Bachelor's) program consists of four years in Engineering Science (option 5A), and the post-graduate programs are taken in the department of Aerospace Studies of the School of Graduate Studies.

(i) *Undergraduate Program.* The details of the undergraduate program are given in this Calendar (page 40) and are seen to consist mainly of intensive studies in the fundamentals of mathematics, physics, and the engineering sciences. In the final two years the program is oriented to the special needs of the aerospace field, and includes some highly specialized courses. The aerospace-related subjects in these two years are taught by the faculty of the Institute for Aerospace Studies. Graduates of this program are able to fill a variety of positions in education, industry and government, but the fifth year (see below) is recommended for those who wish to improve their qualifications for employment as aerospace engineers.

(ii) *Graduate Program.* If the student's academic record in the undergraduate program meets the requirements for admission to the School of Graduate Studies, he may pursue during a fifth year a program as a candidate for the M.A.Sc. or M.Eng. degree in the (graduate) department of Aerospace Studies. Details of entrance regulations and courses of study are given in the Calendar of the School of Graduate Studies. The facilities of the Institute for Aerospace Studies are available to the student for research or project work. For details of research fields, assistantships, scholarships and demonstratorships, students should consult the secretary of the graduate department.

It should be noted that a student who has graduated in another branch of engineering, or in science or mathematics, and who desires to qualify as an aerospace engineer may be admitted to the graduate program. In that case the courses leading to the M.A.Sc. or M.Eng. degree will be arranged on an individual basis so that any deficiencies in undergraduate training are made up.

The facilities of the Institute are available for further graduate study and research leading to the Ph.D. degree.

Outline of Courses

On the following pages are brief outlines of the courses prescribed for students in the Faculty of Applied Science and Engineering, listed in alphabetical order of the prefixes (AER, CIV, etc.) which identify the teaching department. The suffix following the course number indicates the term in which the course is given; the second line of the description shows the program and year in which the course is prescribed, and the number of hours of lectures and laboratory or tutorial work per week, and the weight units assigned to the course. For example:

MEC 205F	Dynamics			
II–7		3	2	9

indicates a fall-term course offered by the Department of Mechanical Engineering for students in Second Year Electrical Engineering. The course consists of 3 hours lectures and 2 hours laboratory per week, and has a weight of 9 units.

The interpretation of the suffixes which follow course numbers is as follows:

Suffixes to course numbers:*

F: a first-term course.

S: a second-term course.

F/S: indicates that the course is available in both terms.

C: the first half of a full year course taken in the Faculty of Arts and Science; Engineering students will be evaluated at the end of the first term.

D: the second half of the above. (Both parts of the course must be taken.)

X: when added to a course offered in the Faculty of Arts and Science, signifies that a laboratory course with a different number has been added for Engineering students.

Y: a half-course in the Faculty of Arts and Science given over a full year.

*The absence of a suffix indicates that the course continues over both terms.

AEROSPACE STUDIES

AER 301F MECHANICS

III – 5a, 5g, 5nt, 5p 3 – 8

Kinematics, translations and rotation, reference frames. Dynamics of a particle and of a system of particles. Work, energy momentum. Linear oscillator. Simple pendulum (nonlinear). Kepler problem. Collisions. Langrangian mechanics, generalized co-ordinates, Hamiltonians, constraints. Rigid bodies; kinematics, inertia, matrix, Euler's equations, characteristic modes and frequencies. Hamilton's principle. Topics selected by class from: astrodynamics, Hamiltonian mechanics, special relativity, continuous media, and others. Reference Books: *Principles of Dynamics, Greenwood Classical Mechanics*, Goldstein.

H. S. Ribner

AER 302F MECHANICS OF STRUCTURES

III – 5a 3 – 9

Basic theorems and principles in the theory of structures (strain energy, virtual displacements, minimum total potential energy). General theory of bending of beams (unsymmetrical bending, thin walled structures, shear flow in multiflanged beams, open and closed sections). General theory of torsion (thin walled structures, multicell structures, shear centre). Theory of elastic instability (buckling of slender elastic struts, flat and curved plates, shells). Plane stress problems (Airy and Prandtl stress functions).

R. C. Tennyson

AER 303F AEROSPACE LABORATORY I

III – 5a – 3 6

Students will perform some prepared experiments and/or carry out an individual project in the subject areas Mechanics and/or Mechanics of Structures.

AER 304S AEROSPACE LABORATORY II

III – 5a – 3 6

Students will perform some prepared experiments and/or carry out an individual project in the subject area Fluid Mechanics.

AER 305S FLUID MECHANICS

III – 5a 3 – 9

Introductory concepts and idealizations of real fluids; mathematical theory of incompressible inviscid flow; viscous flow and turbulence. Reference Books: *Fundamentals of Hydro and Aeromechanics* – Prandtl and Tietjens; *Applied Hydro and Aeromechanics* – Prandtl and Tietjens; *Fluid Dynamics* (1948 ed.) – Streeter. Advanced reading: *Hydrodynamics* – Lamb; *Incompressible Aerodynamics* – Thwaites.

J. W. Locke

AER 401F AERODYNAMICS

IV – 5a 3 – 9

Aerodynamics of Flight: drag, propulsion, wing theory. Mechanics of flight: performance of aircraft, stability and control of aircraft. Reference Books: *Aerodynamics of V/STOL Flight* – B. W. McCormick, Jr.; *Foundations of Aerodynamics* – Kuethe and Schetzer. *Flight Mechanics – I: Theory of Flight Paths* – A. Miehle; *Dynamics of Flight – Stability and Control* – Etkin.

J. H. De Leeuw

AER 402F SPACE FLIGHT DYNAMICS

IV – 5a 2 – 6

Gravity Potential of an Oblate Earth. The Kepler Problem. Perturbations on Earth Orbits. Lambert's Theorem. Time of Flight. The Impulsive Thrust Approximation. The Patched Conic Approximation. Orbit Transfer. Interplanetary Flight. Launch Windows and the Gravity Turn. The Restricted Three Body Problem. Jacobi's Integral. Libration Points. Lunar Trajectories (Apollo). Torques. Attitude Dynamics of a Rigid Satellite in a Circular Orbit. Dissipation Effects. Flexibility Effects. Long Period Effects of Torques. Active Attitude Control. Problems of Planetary Entry.

P. C. Hughes

AER 403F ADVANCED MECHANICS OF STRUCTURES

IV – 5a 2 – 6

Matrix analysis of redundant structures is studied, including the force and displacement methods. Flexibility and stiffness matrices for structural elements are derived and solutions given for the effects of thermal strains and structural cutouts. Automated techniques for determining redundant members are presented. The finite element approach is derived and applied to plates and shells. The method of individual displacements is also considered with solutions given for buckling loads, natural frequencies and stress distributions in structures. Reference Books: *Theory of Matrix Structural Analysis* – J. S. Przemienicki, McGraw-Hill, New York (1968). *The Finite Element Method in Structural and Continuum Mechanics* – Zienkiewicz, O. C., and Cheung, Y. K., McGraw-Hill, London (1967).

R. C. Tennyson

AER 404F PHYSICS AND MECHANICS OF SOLIDS

IV – 5a 3 – 9

Properties of solids, the factors on which they depend. Structural imperfections, atom movements, dislocation theory. Deformation and failure of metals. Metal fatigue, service loads and service load laboratory simulation, statistical evaluation of fatigue data. Microstructural changes in metal due to fatigue, fatigue damage accumulation, crack initiation and propagation. Environmental effects on service life under fatigue, surface protection. Reference Books: *Elements of Materials Science* –

Van Vlack. *Inelastic Behaviour of Engineering Materials and Structures* – Freudenthal.

G. K. Korbacher

AER 405F PLASMADYNAMICS

IV – 5a 3 – 9

Electrostatics, magnetostatics, Maxwell's equations, E-M wave propagation, plasma equations of motion and conduction, MHD approximation, tensor conductivity, Alfvén, magnetoacoustic and MHD shock waves, simple flow problems in magnetogasdynamics, applications to propulsion and power generation. Reference Books: *Engineering Magnetohydrodynamics* – Sutton and Therman. *The electromagnetogasdynamics of Fluids* – Hughes and Young. *Magnetofluidmechanics* – Cambel.

S. J. Townsend

AER 406F ENGINEERING DESIGN I

IV – 5a – 3 8

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Drawings and reports are prepared as required.

L. D. Reid

AER 407S ENGINEERING DESIGN II

IV – 5a – 3 8

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Drawings and reports are prepared as required.

L. D. Reid

AER 408F AEROSPACE LABORATORY III

IV – 5a – 6 8

Students will perform some prepared experiments and/or carry out an individual project on an approved topic.

AER 409S AEROSPACE LABORATORY IV

IV – 5a – 6 8

Students will perform some prepared experiments and/or carry out an individual project on an approved topic.

AER 410S GASDYNAMICS

IV – 5a 3 – 9

Some fundamental phenomena that occur in a compressible flow are treated. Basic thermodynamics and the equations of inviscid and viscous compressible flows are reviewed. Compressible flow in nozzles, diffusers, and ducts with viscous and diabatic effects, and shock and expansion waves in both steady and nonstationary flows including high temperature effects that cause departures from the perfect gas law and equilibrium, are discussed. Reference Books: *Elements of Gasdynamics* – Lipemann and Roshko. *Dynamics and Thermodynamics of Compressible Fluid Flow* – Shapiro. *Handbook of Supersonic Aerodynamics, Section 18, Shock Tubes* – Glass and Hall. *Introduction to Physical Gasdynamics* – Vincenti and and Kruger.

I. I. Glass

AER 411S STABILITY AND CONTROL OF AIRCRAFT

IV – 5a 2 – 6

Introduction to the dynamic stability and control-response of aircraft. Equations of mation for small perturbations from steady flight; longitudinal stability; lateral stability; response to throttle, elevator, aileron, rudder; flight in turbulence. *Reference* Book: *Dynamics of Flight-Stability and Control* – Etkin.

B. Etkin

AER 412S AEROELASTICITY

IV – 5a 2 – 6

Static aeroelastic phenomena are studied, including divergence of slender wings, the effect of low aspect ratio, sweep and wing-aileron interaction. Various methods of solution are considered such as closed form, matrix format iteration and the Rayleigh-Ritz approach. A study of vibration and flutter of wings and control surfaces is presented with particular emphasis on those parameters which affect flutter speed. Reference Books: *An Introduction to The Theory of Aeroelasticity*, Fung, Y. C., Dover Paperback Publications (1969).

R. C. Tennyson

AER 413S PHYSICS OF RADIATING GASES

IV – 5a 3 – 9

Review of atomic and spectroscopic theory, line radiation, Einstein coefficient, optical depth, population inversion and lasers, applications of lasers, spectral line broadening, local thermodynamic equilibrium, plasma spectroscopic techniques, vibration and rotation of molecules.

R. M. Measures

AER 414S TRANSPORT PHENOMENA

IV – 5a 2 – 6

A fundamental treatment of selected phenomena in fluid dynamics in which the transport of momentum, mass and energy are the key underlying processes, i.e. dynamics of viscous fluids; boundary layers; diffusion. Reference Book: *Transport Phenomena* – Bird, Stewart and Lightfoot.

G. W. Johnston

APPLIED MATHEMATICS

APM 236S NUMERICAL METHODS

III – 8 2 2 8

Solution of non-linear equations, approximation, quadrature, solution of systems of linear equations, eigenvalues and eigenvectors, differential equations. Exercises requiring use of a computer will be assigned.

N. A. Derzko

APM 281F NUMERICAL METHODS

II – 5 2 1 7

Roots of equations, interpolation, quadrature, numerical solution of ordinary differential equations, matrix calculations, eigenvalues, roundoff errors.

J. C. Mason

APM 381F NUMERICAL METHODS I

III – 4 2 2 8

Roots of equations, interpolation, approximation theory, quadrature, numerical solution of ordinary differential equations.

R. L. Johnston

APM 386S NUMERICAL METHODS II

III – 4 2 2 8

Matrix calculations eigenvalues, roundoff errors, random numbers, extrema of functions of several variables.

E. V. Swenson

APM 391F DIFFERENTIAL EQUATIONS

III – 8, III – 4 (elective) 2 2 8

First and second order ordinary differential equations, operational methods, variation of parameters, solution in series. Bessel and Legendre functions, the Laplace transform.

F. V. Atkinson

APM 441 DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS

IV – 5 2 – 6, 2 – 6

Equations of second order, Green's functions, distributions, Hilbert space, elements of functional analysis, eigenvalues and eigenfunctions with applications to wave propagation, heat flow and boundary value problems.

W. Lakin

APM 481F NUMERICAL METHODS

IV – 3 2 2 8

Roots of equations, interpolation, quadrature, numerical solution of ordinary differential equations, matrix calculations, eigenvalues, roundoff errors.

J. C. Mason

APM 486S COMPUTATIONAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS

IV – 5cs 2 1 7

Initial value problems for partial differential equations. Consistency, convergence, stability. Boundary value problems. Mixed initial-boundary value problems. Difference schemes for nonlinear problems.

R. L. Johnston

APPLIED SCIENCE AND ENGINEERING — INTERDEPARTMENTAL

APS 100F & S COMPUTER PROGRAMMING

I – 1, 3, 4, 6, 7, 8, 9 1 3 6

The digital computing system as a device for numeric and non numeric transformation of numbers and symbols. Constants, variables, and arrays; arithmetic and logical expressions; functions. Algorithms, represented by flow chart and computer languages. Conditional branching and looping; iteration; sub-programs; input/output. All of the above will be illustrated and implemented using the FORTRAN IV language. Applications will include root finding, numerical integration, sorting, iterative design and graph plotting.

APS 101S ENGINEERING DESIGN

I – 1, 3, 4, 5, 6, 7, 8, 9 (elective) 3 1½ 10

Lectures will deal with the sequence of design steps by which engineers find acceptable solutions for stated technological needs. These include need definition, ideation, problem modelling, feasibility and economic analysis, the decision process, specification and presentation. A series of seminars will be used to study "case" problems and to consider such topics as the engineer's responsibility to society. Laboratory time will be devoted to small group design projects.

APS 201S ENGINEERING DESIGN

II – 5 (elective) – 6 8

This course provides instruction and experience in the application of engineering design techniques that lead from a stated technological need to an acceptable solution. Students will work singly or in small groups on design projects and will have lecture/discussion sessions on problem identification, ideation, design criteria, feasibility analysis and decision making. Special topics related to the projects, such as materials, economics, reliability, etc., will be covered as required. At least one of the projects will be carried through to the drawing and specification stage and, if possible, constructed. Class size is limited to twenty students. Reference Books: *An Introduction to Engineering & Engineering Design*, second edition, E. V. Krick, John Wiley and Sons. *Introduction to Engineering Design*, T. T. Woodson, McGraw-Hill.

APS 299 PRACTICAL EXPERIENCE

Students in the programs listed below are required to have, before graduation, practical work of a nature acceptable to the department concerned. This may be obtained during the summer vacations but work done before entering the Faculty may also meet the requirements. Instructions will be issued by the departments concerning the type of work which is acceptable. Practical experience certificate forms may be obtained from the departments and should be returned there when completed.

Program 1	600 hours	Program 8	600 hours
Program 6	600 hours	Program 9	600 hours

APS 300F & S ENGINEERING LAW

II – 3, IV – 3, 4 1 – 2

A subject designed to co-ordinate the practice of engineering and law. Consideration is given to the characteristics, advantages and disadvantages of companies, partnerships, the promotion, organization and financing of companies, the duties of employees to employers, the duties and liabilities of engineers, statutes applicable to engineering works, professional engineering associations, construction contracts, workmen's compensation, trade unions and industrial disputes. Reference Book: *Engineering Law* – Laidlaw, Young, and Dick.

E. S. Langdon, W. O. C. Miller

APS 420S URBAN AND REGIONAL PLANNING

III – 1 (elective); IV – 1 (elective) 3 2 9

Spatial distribution of land use related to physical, ecological and transportation factors. Economic alternatives for the selection of industrial, residential and recreational location. Land use planning concerning natural resources, resource potential and conservation. Legal aspects of planning. Mathematical modelling and optimization of land use. (To be offered jointly by the Departments of Urban and Regional Planning and Civil Engineering.)

APS 478, 479, 495, 496, 497S, 498S, 499 THESIS IV-5

Every student in fourth year Engineering Science is required to prepare a thesis on an approved subject. Instructions concerning the thesis requirements are issued during the spring term of third year, and copies may be obtained in the division office. The weight allocated in each term of each option is shown in the fourth year curriculum.

The thesis will be graded after submission in the spring term, and the grade included in the weighted average for that term only. The weight assigned will be the sum of the weights for both terms.

CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

CHE 100F CHEMISTRY

I – 1, 3, 4, 6, 7, 8, 9 3 3 12

An introductory course in physical chemistry involving problems dealing with industrial and engineering applications. Topics discussed are stoichiometry and the mole concept, ideal and real gas behaviour, phase equilibria and colligative properties of solutions, chemical and ionic equilibrium, electrochemistry, thermochemistry and chemical kinetics.

The lecture course is supplemented by a series of laboratory experiments illustrating the principles discussed. Experiments include a gas-chromatographic study of fuel combustion, caustic-chlorine and sulphuric acid pilot plants, freezing point depression, molecular weight determination, vapour pressure, steam and binary distillations, qualitative analysis, heat of neutralization, kinetics, corrosion, pH and electrochemistry.

S. Sandler and Staff in Chemical Engineering

CHE 101S CHEMICAL ENGINEERING PROJECTS

I – 1, 3, 4, 5, 6, 7, 8, 9 (elective) 3 1½ 10

A course concerning several topics of wide interest to engineers, in which each student may choose *three* Chemical Engineering Projects during the term. Each five week project is given by a specialist in his field of interest and includes laboratory sessions during which the student may design and execute a particular investigation related to the lecture course. Some of the projects include:

Polymer Engineering
Reinforced Plastics Engineering
Electrochemical Energy Sources
Industrial and Ecological Applications of Inorganic Complexes
Environmental Chemistry
Concepts of Fluid Flow
Separation Processes
Combustion
Bio-Engineering

A topic will be given in any year in which more than 20 students elect to take it.

R. T. Woodhams and Staff in Chemical Engineering

CHE 102F CHEMISTRY

I – 5 3 3 10

(CHE 100F with alternative assignments.)

W. H. Burgess and Staff in Chemical Engineering

CHE 201F PHYSICAL CHEMISTRY I

II – 6 2 – 5

The following topics are treated: equations of state, principle of corresponding states, reaction stoichiometry, first law of thermodynamics and thermochemistry, phase equilibrium and phase diagrams.

R. W. Missen

CHE 202S PHYSICAL CHEMISTRY II

II – 6 2 3 8

This course provides an introduction to chemical thermodynamics and chemical kinetics. The second law of thermodynamics is discussed and applied to solutions, phase equilibrium, reaction equilibrium, including cell reactions and surfaces; in kinetics attention is focussed on ideal reactor models, rate laws, reaction mechanisms and catalysis. Laboratory work involves experiments for both 201F and 202S.

R. W. Missen

CHE 203F ANALYTICAL CHEMISTRY LABORATORY

A voluntary course beginning August 25th is offered by the Senior Staff in the Department of Chemical Engineering and Applied Chemistry. The course is designed to provide experience in precise analytical measurements. Problems relevant to industry and the ecological environment will be examined. Application should be made to the Chairman of the Department by April 30th.

J. W. Smith and Senior Staff in Chemical Engineering

CHE 204F ANALYTICAL CHEMISTRY

II – 6 2 12 14

Experimental work and lectures to illustrate the principles of equilibrium and coordination chemistry as applied to quantitative and qualitative analysis. Students may elect an independent experimental project under the direction of a staff member after completing a minimum number of set experiments. Textbooks: *Quantitative Chemical Analysis* – Fischer and Peters.

J. W. Smith and Staff in Chemical Engineering

CHE 205F INDUSTRIAL PROCESS OPERATIONS I

II – 6 3 2 9

The theory of momentum and heat transfer and the fundamentals of momentum, heat and mass balances of chemical engineering practice are discussed. A tutorial problem class accompanies this course. Textbooks: *Principles of Unit Operations* – Faust et al. *Basic Principles and Calculations in Chemical Engineering* – Himmelblau.

I. H. Spinner, W. G. MacElhinney

CHE 206S INDUSTRIAL PROCESS OPERATIONS II

II – 6 3 8 13

The fundamentals of transfer processes are discussed with particular reference to heat transfer operations in chemical engineering. A laboratory illustrating the principles and practice of transfer operations is also given. A tutorial problem class accompanies the lecture material. Textbooks: *Principles of Unit Operations* – Faust et al. *Unit Operations of Chemical Engineering* – McCabe & Smith.

W. G. MacElhinney, J. W. Smith, I. H. Spinner

CHE 207S ORGANIC CHEMISTRY

II – 6 3 3 10

An introductory lecture and laboratory course in organic chemistry, with emphasis on structure. Textbook: *Modern Organic Chemistry* – Griffin.

W. H. Rapson

CHE 208S APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

II – 6 2 1 6

Application of differential equations to problems of chemical engineering interest. Emphasis is on the formulation of differential equations together with their solution by analytical and numerical methods. Reference Book: *Applied Differential Equations* – M. R. Spiegel.

R. Luus

CHE 209F CHEMICAL SYSTEMS

II – 5 3 3 9

The themes discussed are conservation, equilibrium and rate of change in chemical systems. These are applied to topics in various engineering fields. Laboratory work illustrating the principles with emphasis on individual projects accompanies the lectures.

C. E. Chaffey

CHE 214F INORGANIC CHEMISTRY I

II – 9a 2 – 7

CHE 217F with alternative assignments. *R. E. Jervis*

CHE 215S INORGANIC CHEMISTRY II

II – 9a 2 – 8

CHE 218S with alternative assignments.

R. L. Hummel, R. E. Jervis

CHE 217F INORGANIC CHEMISTRY I

II – 6 2 – 5

Periodicity in physical and chemical properties of the elements are studied in relation to atomic structure. Descriptive chemistry of representative and some transition elements are correlated with structure. Textbook: *University Chemistry* – Mahan (second ed.).

R. E. Jervis

CHE 218S INORGANIC CHEMISTRY II

II – 6 2 – 5

Useful quantum models are developed for atoms and for atomic and molecular orbital bonding mechanisms. Concepts discussed include: electronegativity, Z-effective, ionic compounds, covalent bond lengths and energies, partial ionic character of bonds, co-ordination and complexation.

R. L. Hummel, R. E. Jervis

CHE 301F THERMODYNAMICS AND KINETICS I

III – 6 3 8 14

The power sources which have supported our civilization are ultimately based on the exploitation of chemical potentials. This course is an examination of the ultimate energy transformation and the rates at which they may be provided, together constituting a complete description of the Gibbsian power sources.

Laws of conservation and the concept of entropy together with theories of chemical reaction rates and mechanisms of selected chemical processes will be discussed in an historical context. These concepts will be illustrated by chemical engineering problems encountered in the design and operation of the means of production.

W. F. Graydon, W. H. Burgess

CHE 302S THERMODYNAMICS AND KINETICS II

III – 6 3 8 15

A re-statement of the material described in course CHE 301F with additional quantitative applications taken from Chemical Engineering practice.

W. F. Graydon, W. H. Burgess

CHE 303F THERMODYNAMICS AND KINETICS I

III – 5a, c 2 3 9

Course 301F with reduced laboratory or tutorial assignments.

W. F. Graydon

CHE 304S THERMODYNAMICS AND KINETICS II

III – 5c 2 3 9

Course 302S with reduced laboratory or tutorial assignments.

W. F. Graydon

CHE 305F APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

III – 6 2 – 6

Analysis and solution of chemical engineering problems which require knowledge of the rational design of experiments, treatment of experimental data and tests of hypotheses. The application of probability to selected topics of chemical engineering interest. Reference Books: *Probability and Statistics for Engineers* – I. Miller and J. E. Freund. *Engineering Statistics* – Bowker and Lieberman.

I. H. Spinner

CHE 306S FUNDAMENTAL PROCESS MODELLING AND SIMULATION

III – 6 (elective) 2 1 6

Modelling of elementary chemical engineering processes leading to differential equations and arising from the application of the principles of thermodynamics, kinetics, fluid mechanics, and heat and mass transfer to chemical engineering problems.

D. Basmadjian, M. E. Charles, I. H. Spinner

CHE 307S ORGANIC CHEMISTRY OF HIGH POLYMERS

III – 6 (elective) 2 1 6

The synthesis, mechanism of formation, and characterization of typical organic high polymers.

W. H. Rapson, H. L. Williams, R. T. Woodhams, I. H. Spinner

CHE 308S CHEMICAL ENGINEERING ECONOMICS

III – 6 (elective) 2 1 6

A systems approach to the feasibility of chemical engineering projects. The objectives, profitability, probability profiles, benefit-cost and social risk analyses are discussed, as are criteria for engineering decision-making, responsibilities of engineers in project implementation and range of typical Canadian and overseas engineering problems. Textbook: *Plant Design and Economics for Chemical Engineers* – Peters and Timmerhaus. Reference Book: *Fundamentals of Cost Engineering in the Chemical Industry* – Bauman.

M. Wayman

CHE 309F ORGANIC CHEMISTRY

III – 6 3 9 14

A continuation of course 207S. Textbook: *Modern Organic Chemistry* – Griffin.

J. G. Breckenridge

CHE 310F MASS TRANSFER OPERATIONS I

III – 6 2 2 8

The study of the fundamentals of mass transfer. Theory and practice of applications to gas-liquid mass transfer processes, including gas absorption, stripping, drying and humidification. Textbook: *Mass Transfer Operations*, 2nd ed. – R. E. Treybal.

D. Mackay, O. Trass, R. F. Hunter

CHE 311S MASS TRANSFER OPERATIONS II

III – 6 2 5½ 11

The study of distillation, including extractive and azeotropic distillation, solvent extraction, adsorption, membrane separation and other separation processes. Illustrative laboratory experiments. Textbook: *Mass Transfer Operations*, 2nd ed. – R. E. Treybal.

D. Mackay, O. Trass, R. F. Hunter

CHE 312F MASS TRANSFER OPERATIONS I

III – 5c 2 2 9

Course 310F but with alternative assignments.

D. Mackay, O. Trass, R. F. Hunter

CHE 313S MASS TRANSFER OPERATIONS II

III – 5c 2 1½ 8

Course 311S with no laboratory assignments, and alternative tutorial assignments.

D. Mackay, O. Trass, R. F. Hunter

CHE 314S FLUID MECHANICS

III – 6 3 2½ 10

Laminar and turbulent flow of Newtonian and non-Newtonian fluids, fluid-particle systems, two-phase flow, pumps; important application of fluid mechanics in the process industries and the environment.

M. E. Charles

CHE 315F CHEMICAL ENGINEERING PROBLEMS AND LABORATORY I

III – 5c – 2 7

Laboratory experiments and problems illustrating selected topics discussed in subject CHE 301F.

W. F. Graydon

CHE 316S CHEMICAL ENGINEERING PROBLEMS AND LABORATORY II

III – 5c – 2 7

Laboratory experiments and problems illustrating selected topics discussed in subjects CHE 302S and CHE 317S.

W. F. Graydon

CHE 317S MOLECULAR ENGINEERING

III – 5c 3 – 8

A basic course in organic and inorganic chemistry which emphasizes the fundamental mechanisms of chemical reactions and catalysis with reference to their use in industrial processes.

R. T. Woodhams

CHE 401F CHEMICAL ENGINEERING LABORATORY

IV – 6 – 9 12

Bench and pilot plant experiments are carried out to study a variety of unit operations such as fluidization, heat transfer, evaporation, filtration, distillation, extraction and absorption. Modern control instruments are discussed and operated. One laboratory report per week.

R. F. Hunter and Staff in Chemical Engineering

CHE 402F CHEMICAL ENGINEERING THERMODYNAMICS

IV – 6 (elective) 2 1 7

Thermodynamic properties of real gases and of ideal and non-ideal liquid solutions. Chemical reaction equilibria. Selected problems.

W. H. Burgess

CHE 403F INTERFACE KINETICS

IV – 6 (elective) 2 1 7

A course on the chemical kinetics of catalytic processes.

W. F. Graydon

CHE 404F MOLECULAR THERMODYNAMICS

IV – 6 (elective) 2 1 7

Molecular thermodynamics is the use of classical and statistical thermodynamics, together with knowledge of molecular behaviour, in equilibrium analysis of chemical systems. After development of principles and working tools, applications are made to fluid behaviour, and phase and reaction equilibrium.

R. W. Missen

CHE 405F CHEMICAL PLANT DESIGN

IV – 6 (elective) – 6 7

This is a course based on synthesis and creativity. Teams of about 6 students each design and cost a chemical plant. The plants are chosen based on current Canadian needs and interests.

M. Wayman

CHE 406F CHEMICAL PLANT DESIGN

IV – 5c (elective) – 6 8

CHE 405F with alternative assignments. *M. Wayman*

CHE 407F PROCESS MODELLING AND SIMULATION

IV – 6 (elective) 2 3 7

The mathematical modelling of steady and unsteady states in typical processes involving fluid flow, heat and mass transfer, vapour-liquid equilibria, and chemical reaction. Solution by analytical, analog and digital methods.

D. Basmadjian, M. E. Charles, I. H. Spinner

CHE 408F STRATEGY OF PRODUCT AND PROCESS DEVELOPMENT

IV – 6 (elective) 2 3 7

The strategical approaches needed for the solution of engineering problems involving the creation of novel unit operation equipment and novel processes, both for chemical and non-chemical products.

R. F. Hunter, I. H. Spinner

CHE 409F STRATEGY OF PRODUCT AND PROCESS DEVELOPMENT

IV – 5c (elective) 2 3 8

CHE 408F with alternative assignments. *R. F. Hunter, I. H. Spinner*

CHE 410F ADVANCED SEPARATION PROCESSES

IV – 6 (elective) 2 1½ 7

Theory and application of a number of separation processes, including multicomponent distillation (using computational techniques), azeotropic and extractive distillation, liquid extraction, transient behaviour and cyclic processes, and solid-liquid contacting operations. Illustrative design problems.

D. Mackay, O. Trass

CHE 411F CONVECTIVE HEAT AND MOMENTUM TRANSFER

IV – 6 (elective) 2 1½ 7

A continuation of earlier courses on convective heat and momentum transfer in flowing fluids. A phenomenological approach based on current research. The effect of factors such as roughness is considered in detail.

J. W. Smith

CHE 412F PIPELINE TRANSPORTATION

IV – 6 (elective) 2 1½ 7

A course based on the theory and practice of moving gases, liquids and solids by pipeline both within chemical plants and over long distances. Operating pipeline systems are used as examples, and the course includes a feasibility and design study.

M. E. Charles

CHE 413F COMPOSITE MATERIALS

IV – 6, 8 (elective) 2 1 7

A course on the fundamentals of composite material design, fabrication and evaluation. Topics will emphasize recent developments in the reinforcement of plastics and metals using fibers, flakes, and other particulate fillers. Examples will include the use of such composites in automotive, marine, aircraft, building construction and allied engineering applications.

M. R. Piggott, R. T. Woodhams

CHE 415F POLYMER ENGINEERING

IV – 6, III – 8 (elective) 2 1 7

The structures and solid state properties of synthetic organic high polymers are related to processing procedures which lead to useful end products with minimal chances of loss of desirable properties.

H. L. Williams

CHE 417F WOOD CHEMISTRY

IV – 6 (elective) 2 1 7

The organic and physical chemistry of cellulose, lignin, hemicelluloses and extractives of wood, and its application to the technology of pulping and bleaching in the manufacture of paper pulps.

W. H. Rapson

CHE 418S APPLIED NUCLEAR CHEMISTRY

III – 8, IV – 6 (elective) 2 1 7

An introduction to the principles and methods of radioisotope chemistry. Applications of nuclear techniques and radioactive materials in chemical technology and in nuclear power generating systems. Topics to be covered include: radioisotope methods of studying chemical reaction mechanisms and kinetics, chemical process development and process control, nuclear reactions applied to chemical analysis (activation analysis), radiation chemical processing.

R. E. Jervis

CHE 420S CERAMICS

IV – 6, 8 (elective) 2 1 7

An introduction to the field of ceramics, including a description of the available raw materials, the production of refractories and glasses, and high-temperature experimental techniques.

D. Barham

CHE 422S CO-ORDINATION CHEMISTRY

6 (elective) 2 – 1 7

The fundamental principles underlying co-ordination compounds: bonding, geometry and isomers, stability, etc., leading to an understanding of examples such as chlorophyll and sequestering agents.

J. G. Breckenridge

CHE 423S ENVIRONMENTAL ENGINEERING

6 (elective) 2 – 1 7

Strategy (management, law, economics) and technology for environmental control of chemical processes. Dispersion and effects of effluents in the environment.

C. R. Phillips

CHE 425S INSTRUMENTAL METHODS

6 (elective) 2 – 1 7

The subject is designed to emphasize the science of chemical instrumentation. The principles, techniques, and applications of gas-chromatographic, opticometric, electrometric and mass-spectometric methods of analysis are studied.

S. Sandler

CHE 426S CHEMICAL BONDING

6 (elective) 2 – 1 7

Periodicity and trends in physical and chemical properties of the compounds of the principal elements are discussed. These are correlated, predicted and classified both in terms of classical concepts and equations of quantum mechanics.

R. L. Hummel

CHE 427S INTRODUCTION TO NUCLEAR ENGINEERING

IV – 6, III – 8 (elective) 2 1 7

Nuclear engineering aspects of: nuclear constitution and properties including cross-section, energetics, radioactivity, production and use of radio-isotopes, neutrons, slowing-down, diffusion of thermal neutrons, fission, the fission reactor. Applications of heat transfer to the reactor core; measurements and control of radiation, exposure of humans to radiation, shielding techniques, reactor kinetics, instrumentation and control.

D. G. Andrews, J. S. Hewitt

CHE 429S INTRODUCTION TO NUCLEAR ENGINEERING

IV – 7 (elective) 2 1½ 7

CHE 427S with alternative assignments.

CHE 430S INTRODUCTION TO NUCLEAR ENGINEERING

IV – 5e (elective) 2 1½ 7

CHE 427S with alternative assignments.

CHE 431S OPTIMAL CONTROL

IV – 6 (elective) 2 1 7

Fundamentals of optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: *Optimal Control of Engineering Processes* – Lapidus and Luus.

R. Luus

CHE 432S CHEMICAL REACTORS

IV – 6 (elective) 2 1 7

An introduction to the rational design and analysis of chemical reactors. Topics are: chemical kinetics and development of the rate law, including homogeneous and heterogeneous systems and catalysis; reactor models (batch, tubular, stirred-tank), including isothermal, non-isothermal and adiabatic operation. Reference Books: *Chemical Reactor Theory* – K. G. Denbigh, *Chemical Reaction Engineering* – O. Levenspiel.

R. W. Missen

CHE 433S INTERFACIAL PHENOMENA AND DISPERSE SYSTEMS

IV – 6 (elective) 2 1 7

A course in surface chemistry, interfacial phenomena and disperse systems (aerosols, emulsions, colloids, surface films, etc.) with chemical engineering applications. Textbook: *Interfacial Phenomena* – Davies, J. F. and Rideal, E. K.

C. R. Phillips

CHE 434S CHEMISTRY OF ORGANIC COMPOUNDS

IV – 6 (elective) 2 1 7

A course based on the structures, reactions and properties of carbohydrates, proteins, lipids, dyes and steroids including the toxicology of some industrial organic compounds.

P. Y. Wang

CHE 435F RATE PROCESSES I

IV – 5c 3 – 8

Introduction to momentum, heat and mass transfer. Transport properties from kinetic theory of gases. Fluid flow concepts, integral mass, force and energy balances, Bernoulli's equation, friction. Equations of motion and boundary layer equations. Turbulent transport. Compressible flow.

O. Trass

CHE 436S RATE PROCESSES II

IV – 5c 3 – 8

Total energy and thermal energy equations. Heat Transfer: Fourier's laws, heat transfer coefficients and equations. Component mass balances, mass transfer coefficients and Fick's laws. Momentum, heat and mass transfer analogies. Applications of the above fundamentals.

O. Trass

CHE 437F OPTIMAL CONTROL OF CHEMICAL SYSTEMS

IV – 5c (elective) 3 1½ 8

Fundamentals to optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: *Optimal Control of Engineering Processes* – Lapidus and Luus.

R. Luus

CHE 438S THERMODYNAMICS OF CHEMICAL SYSTEMS

IV – 5c (elective) 3 – 8

Development of the principles of chemical equilibrium and of statistical mechanics; application to both non-reacting and reacting systems, with emphasis on behaviour of multicomponent mixtures and complex reactions, and the calculation of thermodynamic properties in the ideal-gas state. Reference Books: *The Principles of Chemical Equilibrium* – K. G. Denbigh, *Molecular Thermodynamics of Fluid Phase Equilibria* – J. M. Prausnitz.

R. W. Missen

CHE 439S SELECTED TOPICS IN ORGANIC CHEMISTRY

IV – 5a (elective) 3 – 8

A short course in the preparation, structure, and reactions of carbohydrates, proteins, heterocyclic compounds, chemotherapeutic agents, steroid hormones, alkaloids, and synthetic organic polymers.

P. Y. Wang

CHE 440S MODELLING AND SIMULATION OF CHEMICAL SYSTEMS

IV – 5a (elective) 3 – 8

Applications of elements of chemical and physical rate processes to chemical engineering problems. Chemical reactor stability, complex chemical system dynamics and process control. Application of analog, digital simulation, and hybrid computers to the solutions of problems in the above topics.

I. H. Spinner

CHE 441F CHEMICAL ENGINEERING PROJECT

IV – 5a (elective) – 6 8

An experimentally oriented research project.

Senior Staff in Chemical Engineering

CHE 442F NUCLEAR ENGINEERING

IV – 5nt 3 3 11

Nuclear engineering aspects of: nuclear constitution and properties, including cross-section, energetics, radioactivity, production and use of radio-isotopes, neutrons, slowing down, "age" theory, diffusion of thermal neutrons, fission. The age and two-group theories of the reactor core. Reflected reactors (elementary treatment). Reactor kinetics, control and instrumentation. Applications of heat transfer, fluid flow and stress analysis to the reactor core. The measurement and control of radiation. Exposure of humans to radiation. Shielding techniques. Nuclear engineering applications of nuclear and radio-chemistry. Experiments are carried out with radiation sources and instruments, a subcritical reactor, a reactor simulator, pulse height analyzers, fast neutron generators and radioactive tracers.

D. G. Andrews, J. S. Hewitt

CHE 443 ORGANIC CHEMISTRY

Elective 2 – 6, 2 6 10

A special course available to students in any year, other than those enrolled in Program 6, intending to qualify for entry to the Faculty of Medicine. The course is a consolidation of CHE 309F, CHE 207S and some of CHE 307S.

H. L. Williams

CHE 499 THESIS AND PUBLIC DISSERTATION

IV – 6 – 2 2, – 20 21

The thesis will be graded after submission in the spring term and the grade included in the weighted average for that term only. The weight assignment will be the sum of the weights for both terms.

Senior Staff in Chemical Engineering

CIVIL ENGINEERING

CIV 100F APPLIED MECHANICS

I – 1, 3, 4, 6, 7, 8, 9 3 2 10

Statics: The principles of statics are applied to the composition and resolution of forces, moments and couples. The equilibrium states of frames and machines are examined. The distributed load concept is applied to finding centroids, centers of mass and fluid pressure. Dynamics: Applications of the principles of dynamics are discussed for motion on straight and curved paths. Work, energy, power and momentum concepts are applied to particles, systems of particles and rigid bodies. Simpler applications in relative motion are considered. Throughout statics and dynamics the free body concept is emphasized and vector algebra is used where it is most useful.

G. T. Will and Staff in Civil & Mechanical Engineering

CIV 101F MECHANICS (STATICS)

I – 5 2 1 6

Translational and rotational resultants and equilibrants are discussed together with equivalent force systems in two- and three-dimensional space. Emphasis is placed on systems in equilibrium. Distributed forces, applications to structures, friction, method of virtual work, potential energy and stability of equilibrium considered.

S. M. Uzumeri, M. P. Collins

CIV 135F & S ENGINEERING GRAPHICS

I – 1, 3, 4, 6, 7, 8, 9 2 5 8

A course to provide an introduction to graphical communication in contemporary engineering practice. Topics in descriptive geometry and engineering drawing include orthographic projection, single view drawings, spatial analysis, developments and intersections, sketching, preparation of graphs and nomographs and the reproduction of drawings.

C. A. Wrenshall and Staff in Civil Engineering

CIV 136S ENGINEERING GRAPHICS

I – 5 (elective) 2 2½ 8

A course on the use of graphical theories and methods as a means of visual communication in the development of engineering concepts. The lectures and laboratory problems deal with the ideas, problem refinement, solution analysis and solution implementation.

CIV 203S MECHANICS OF MATERIALS

II – 5 (elective) 2 3 8

Structural design philosophy and methods; structural properties of engineering materials; basic relationships between force and deformation of deformable bodies; behaviour of structural components subjected to tension, compression, bending and torsion; design of structures such as pressure vessels, towers and machine elements.

M. P. Collins

CIV 204F MECHANICS OF MATERIALS

II – 8 3 1½ 9

The fundamental relations among stress, strain and applied load are worked out for tension, compression, twisting and bending in the elastic and inelastic ranges, for various engineering materials. The buckling of struts and columns is examined. Laboratory: An experimental study of engineering materials and structural members under various loading conditions.

A. C. Davidson

CIV 205S MECHANICS OF MATERIALS

II – 4 (elective) 2 3 9

An introduction to the elastic behaviour of solids under various load conditions. Stress, strain and deformation relations are determined for members loaded in tension, compression, torsion and bending. Laboratory: An experimental study of engineering materials and structural members under load.

J. D. Barber

CIV 209S ENGINEERING MATERIALS

II – 1, 9c 4 3 6

Deals with the basic principles necessary for the understanding and selection of materials used in Civil Engineering and points out the significance of these in practice. Fundamentals which provide a common basis for the properties of various materials are stressed.

One third of the laboratory time is devoted to demonstrations illustrating the fundamentals covered in the lectures, the remaining time to project work in small groups.

J. Timusk and Staff in Materials Science

CIV 210F STRENGTH OF MATERIALS

II – 1, 9c 3 – 8

An introduction to the elastic and inelastic behaviour of solids under various load conditions. Stress, strain, and deformation relations are determined for members subjected to tension, compression, torsion and bending forces.

J. D. Barber

CIV 211S MECHANICS AND DESIGN OF STRUCTURES

II – 1 4 2 10

This course is primarily an introduction to structural design and topics examined include basic concepts, types of structures, loads, safety factors, specifications and common failure modes. The design of structural components in steel, concrete and timber using the National Building Code is investigated.

Topics to be covered in engineering mechanics include virtual work, energy methods in structural analysis and an introduction to vibration.

S. M. Uzumeri

CIV 240S ENVIRONMENTAL SYSTEMS

II – 1, 9c 2 – 6

Growth and distribution of population; the trend to urbia; cycles of life, energy and materials in nature; biological hazards of pollution. Air pollution: damages, economy, control possibilities. Water pollution: purification and distribution of water, collection and treatment of waste water. Soil pollution: refuse disposal, home disposal of sewage.

A. P. Bernhart

CIV 255F SURVEYING

II – 1 3 3 9

General principles and practice of surveying including: measurement of horizontal distances, horizontal angles, vertical distances. Survey calculations, sources of errors, corrections and adjustments. Route surveying, construction surveying and introduction to airphoto interpretation and photogrammetry.

B. J. Haynes and Staff in Civil Engineering

CIV 260F COMPUTER PROGRAMMING

II – 1 2 2 8

This course continues the study of programming requirements and techniques introduced in course APS 100F-S; the full standard FORTRAN language is used; emphasis is placed on subprogram philosophy and organization, and on flow charts and program documentation. Engineering problem oriented languages such as ICES-COGO and ICES-STRUDL are introduced and used. A few operations at machine language level are examined and illustrated on an emulated simple computer. Some experience is provided in the use of a time-shared interactive computing system.

R. A. Collins

CIV 267F THE ENGINEER AND HIS ENVIRONMENT

II – 1, 9c 2 4 8

An introduction to the role of the engineer in the solution of society's problems. Lectures, seminars and discussion periods by staff of all areas of Civil Engineering and guest speakers. Projects on qualitative solutions to engineering problems. Instruction and practice in presentation of technical data and reports.

Staff in Civil Engineering

CIV 268S THE CIVIL ENGINEER AND HIS PROFESSION

II – 1 2 4 8

An introduction to the different facets of Civil Engineering. Lectures, seminars and discussion periods by staff of all areas of Civil Engineering and guest speakers. Group projects on qualitative solutions to comprehensive engineering problems.

Staff in Civil Engineering

CIV 312F DESIGN OF STRUCTURES II

III – 1 3 2 10

A course on the design of structures with emphasis on the design and analysis of determinate systems. Detailing and fabrication aspects of such structures in steel and in reinforced concrete are examined.

J. Schwaighofer

CIV 313S DESIGN OF STRUCTURES III

III – 1 3 2 10

A course on the design of structures with emphasis on indeterminate systems. Topics considered include the analysis of indeterminate structures by moment distribution and by approximate methods, design of reinforced concrete footings, retaining walls and continuous slabs, introduction to prestressed concrete.

J. Schwaighofer

CIV 321F SOIL MECHANICS

III – 1, IV – 9 2 1 6

Identification and classification of soils for engineering purposes; properties, permeability and drainage characteristics, effective stresses, consolidation and settlement, shearing strength, compaction, stabilization, frost action. Laboratory sessions include identification of soil samples and determination of mechanical properties of soil.

F. De Lory, E. I. Robinsky

CIV 322S FOUNDATIONS

III – 1, IV – 9 2 2 7

Site investigations and sampling, response of soil to load, lateral earth pressure, retaining walls, braced cuts, anchored bulkheads, bearing capacity, shallow foundations, settlement, deep foundations, slop stability. Laboratory sessions are devoted to design problems. (Prerequisite CIV 321F)

F. De Lory, E. I. Robinsky

CIV 328F MINING TECHNOLOGY

III – 9 3 – 6

An introduction to mining practice, its basic unit operations and processes; mine layouts and current mining methods as applied to geological situations and stress environments.

H. R. Rice

CIV 330S TRANSPORTATION SYSTEMS

III – 1 3 2 9

A brief history of Canadian transportation development and a discussion of current policy, regulation and administration structure introduces a comparative study of transportation modes including their cost characteristics. The principles of location, flows on networks and the concepts of capacity and control are studied. The transportation planning process is introduced with emphasis on analytical techniques.

G. N. Steuart

CIV 340S MUNICIPAL ENGINEERING

III – 1 2 2 7

Quantities of water and waste water; hydrologic cycle, analysis of hydrologic data, applications of hydrology to engineering design; waste water collection systems, water distribution systems, refuse disposal, administration and financing of municipal works. Laboratory: Design problems supplementing lecture material.

G. W. Heinke, G. K. Rodgers

CIV 358F SURVEY CAMP

III – 1

At Survey Camp, students obtain further experience in the use of instruments and in the essentials of survey practice. Emphasis is placed on adjustments of levels and transits, route surveys, higher order surveys, topographic surveys, practical astronomy and photo interpretation. Students entering Third Year Civil Engineering will be required to take the Survey Camp from August 23 to September 7, 1971.

The camp is held at Dorset and Gull Lake with students in attendance paying for the cost of their accommodation.

Applications to defer attendance or for exemption from the camp must be made to the secretary of the Faculty before July 15, 1971.

Staff in Civil Engineering

CIV 359F SURVEY CAMP

III – 9

At Survey Camp, students obtain experience in the use of instruments and in the essentials of survey practice. Emphasis is placed on topographic surveying and mapping, underground surveying including shaft plumbing and the use of mine surveying instruments, route surveys, curve layout, earthwork quantity computations, astronomic observations for time azimuth.

The camp will be held at Gull Lake, from August 25 to September 7, 1971. Students attending the camp pay for the cost of their accommodation.

Staff in Civil Engineering

CIV 370F ENGINEERING MATHEMATICS

III – 1 3 2 9

Higher order linear differential equations with constant coefficients, introduction to partial differential equations, numerical integration, solution of initial value problems by numerical methods, introduction to finite differences, solution of linear equations, an introduction to the analogue computer.

G. T. Will

CIV 371F PROBABILITY AND STATISTICS

III – 1 2 2 7

Topics to be considered include definition of probability, binomial, poisson and normal distributions, frequency and sampling distribution. Examples of estimation, hypothesis testing, introduction to experimental design and regression theory.

G. N. Steuart

CIV 375S ENGINEERING ECONOMICS AND DECISION MAKING

III – 1, IV – 1 (elective) 3 2 9

Design as selection between alternatives. Economic efficiency and other goals. The objective function and the use of optimization techniques. Time scale of consequences and its reduction. Interest rate and social rate of return. Market and non-Market valuation. Economic life, replacement and salvage value. Treatment of risk and uncertainty. Public investment. Financing.

CIV 405F ADVANCED STRENGTH OF MATERIALS

IV – 1 (elective) 3 2 9

The following topics are introduced or extended beyond their elementary treatment: torsion of bars having non-circular cross sections; unsymmetrical bending of beams; beams on elastic foundations; curved beams; beam-columns; rings; cylinders, spheres and their interconnection; elementary theory of elasticity; elementary plate theory.

R. A. Collins

CIV 414S ADVANCED ENGINEERING MATERIALS

III – 1, IV – 1 (elective) 3 2 9

A seminar and laboratory course with emphasis on project work at an advanced level in the areas of: properties and analysis of requirements in construction materials; response of materials to service requirements; selection and specification of materials. Materials to be considered include metals, concrete, wood products, polymers and composites.

V. R. Riley

CIV 416F REINFORCED CONCRETE I

IV – 1 (elective) 3 2 9

This course covers the behaviour and ultimate strength of reinforced concrete structures. Members subjected to flexure, axial load, shear and torsion are treated. Detailing of reinforcement, the design of floor systems and the design of shear walls are covered. Emphasis is given to the relationship between recent research results and current building codes.

M. P. Collins

CIV 417S REINFORCED CONCRETE II

IV – 1 (elective) 3 2 9

Prestressed Concrete – tension members, simple span and continuous span flexural members, columns and torsion resisting members. Slender reinforced columns. Yield line methods for slab analysis and design. (Prerequisite CIV 416F)

M. W. Huggins

CIV 418S BEHAVIOUR AND DESIGN OF STEEL STRUCTURES

IV – 1 (elective) 3 2 9

The behaviour of structural elements and structures and their connection by welding and bolting are examined and related to design methods and criteria. Topics to be considered include repeated loading, brittle fracture, elastic-inelastic behaviour, buckling and ultimate capacity.

D. E. Thomson

CIV 419F INDETERMINATE STRUCTURES

IV – 1 (elective) 3 2 9

The study of indeterminate structures is continued beyond that of course CIV 313S. Critical buckling loads are determined for various elastic column situations. Internal forces, support reactions and structural displacements are computed for continuous beams, arches, trusses and frames. An introduction to structural analysis by matrix organization is examined along with some aspects of cable suspended bridges and roofs.

E. Karuks

CIV 420S CONSTRUCTION ENGINEERING

IV – 1 (elective) 3 2 9

This course deals with business and management aspects of construction – construction company organization, construction tenders and contracts, the elements of a construction project, project management, planning and scheduling, job administration, field engineering; and construction methods and equipment. A number of construction sites and construction material manufacturing plants are visited during the scheduled laboratory periods.

CIV 421F FOUNDATIONS AND EARTHWORK

IV – 1 (elective) 3 2 9

Design and construction of: foundations for buildings, bridges and other structures including excavation, footings, piling, caissons; retaining walls, sheet pile bulkheads;

fills, embankments, earth-fill and rock-fill dams including seepage, dewatering and grouting. The laboratory sessions include design problems and studies of case histories.

E. I. Robinsky, F. De Lory

CIV 422S ENGINEERING GEOLOGY

III – 1, IV – 1 (elective) 3 2 9

The study of engineering practice from a geological point of view. The behaviour of rocks and soils in building and engineering construction, foundations, tunnels, dams, and flood-control works with reference to the importance of the mineral composition of earth and rock materials, their geomorphic and geologic features and their stress history. Engineering case studies will include examination of groundwater, frost and landslide conditions, shoreline engineering, construction in permafrost, earthquake problems, and field investigations.

CIV 426F MINE OPERATION AND ADMINISTRATION

IV – 9 (elective) 2 3 6

Operational, financial, legal, and economic considerations in the valuation and management of mineral enterprise. Laboratory work is given on a progressive problem in the estimation of grade and tonnage in an ore situation. While CIV 328F is not a prerequisite, a knowledge of its content would be useful.

H. R. Rice

CIV 427S MINE OPERATION AND ADMINISTRATION II

IV – 9 (elective) 3 3 6

A continuation of the subject matter of CIV 427F which is a prerequisite. In the laboratory the problem evaluated in CIV 427F is pursued through the selection of optimum mining rate and the design of enterprise, complete to the point of financing.

H. R. Rice

CIV 429F AIR PHOTO INTERPRETATION

III – 9, IV – 1 (elective) 3 2 9

The principles of interpretation of aerial photographs; processes of formation and erosion of landforms, both unconsolidated and consolidated, with particular emphasis on glaciation, their patterns as seen on aerial photographs, their identification and evaluation, and the engineering problems involved; location of granular materials; soil mapping; investigations from airphotos for highway, powerline, and pipeline locations, damsites and flood control structures; delineation of drainage areas and drainage structure location; classification of muskeg areas and prediction of depth, land use classification. One day field trip, including field soil testing.

S. J. G. Bird, A. K. F. Turner

CIV 430F TRAFFIC ENGINEERING

IV – 1 (elective) 3 2 9

Introduction to the basic principles and methods of Traffic Engineering. Driver, vehicle and roadway characteristics. Description and measurement of traffic streams. Micro and macroscopic properties. Highway intersection capacity. Traffic accidents, their relation to design and their control. Traffic signing and signalization. Area traffic control and surveillance. Illumination. Parking. Reference Book: *Traffic Engineering Handbook.*

E. Hauer

CIV 431F TRANSPORTATION PLANNING

IV – 1 (elective) 3 2 9

This course deals with the transportation planning process, with emphasis on urban and regional applications. Surveys and data collection, mathematical models and transportation demand analysis, transit and highway system alternatives, methods of project and systems evaluation. Reference Book: *Principles and Techniques of Predicting Future Demand for Urban Area Transportation*, Martin, Memmott and Bone, M.I.T. Press.

R. G. Rice

CIV 432S HIGHWAY ENGINEERING

IV – 1 (elective) 3 2 9

A basic course in which the following topics are examined: highway systems and geometric design; highway materials and their behaviour; and pavement systems. The laboratory part of the course is mainly devoted to a design project.

M. M. Davis

CIV 440F POLLUTION CONTROL ENGINEERING

IV – 1 (elective) 3 2 9

This course considers the control of air, water and soil pollution. Topics in air pollution include its effect on man's environment, types of air pollution, influence of man and his planning and available equipment to control exhaust gases. Topics in water pollution include quantities and qualities, purification, treatment of municipal and industrial waste water, self-purification of rivers. Topics in soil pollution control include depositing of solid wastes, infiltration of treated waste water into soil.

A. P. Bernhart, K. Reichert

CIV 450F WATER RESOURCES AND HYDROLOGY

IV – 1 (elective) 3 2 9

The availability and management of water for optional use in the broadest sense. Qualitative and quantitative evaluation of surface and ground water sources. Rainfall, run-off and stream-flow analysis. Groundwater recharge. Storage, flood control, diversion and related hydraulic structures. Uses of water and forecasting the demand. Quality standards, ecological, economic, sociological, legal and political factors affecting water management.

A. C. R. Albery

CIV 455F PHOTOGRAMMETRY AND REMOTE SENSING

IV – 1 (elective) 3 2 9

Camera as a measuring instrument. Materials and execution of ground and aerial photography. Simple geometry of the photograph. Stereoscopic observation. Simple measurements from stereo pairs of photographs. Methods and means of reconstruction of an exact 3-dimensional model of the photographed object. Applications in various fields such as surveying, mapping, engineering, forestry, architecture, geography, etc. Characteristics of electromagnetic spectrum and the basis for remote reconnaissance. Discussion of laws governing absorption, reflection, emission and scattering of radiant energy. Spectral characteristics of natural objects. Examples of remote sensing in natural resource studies. Discussion of earth resource satellites, their orbits, equipment, data recovery.

R. C. Gunn

CIV 456S ENGINEERING APPLICATIONS OF SURVEYING

III – 1, IV – 1 (elective) 3 2 9

Theory, methods and instrumentation of engineering surveys. Special applications in Civil Engineering structures such as: bridges, dams, tunnels, highways, airports, powerlines and pipelines, as well as deformation of structures and crustal movement studies. Introduction to hydrographic surveying. Optical tooling and industrial applications.

B. J. Haynes

CIV 457S GEODETIC CONTROL SURVEYS

IV – 1 (elective) 3 2 9

Geodetic Control Surveys provides a basis for the design and analysis of urban and regional surveys. Topics studied include: establishment of vertical and horizontal datums and their relation to municipal and national mapping, reduction of field measurements to a datum surface, study of electromagnetic survey systems, some elements of physical and geometric geodesy, the relation between astronomic and geodetic coordinates and their determinations, the adjustment and statistical analysis of survey measurements with the application of the electronic computer.

R. C. Gunn

CIV 474S PUBLIC SPEAKING

IV – 1 – 2 3

A subject emphasizing student participation and designed to develop facility in oral presentation before groups. Beginning with short talks, students move on to longer prepared talks on technical subjects. Experience and observation are also offered in the conduct of meetings.

Staff in Civil Engineering

CIV 475F ADMINISTRATION AND MANAGEMENT

IV – 1 2 – 6

An introduction to the various management functions involved in operating a business; including planning, organizing, staffing, directing, controlling and labour relations. Individual proprietorships, partnerships and limited company operations are discussed.

K. A. Selby, H. L. Macklin

CIV 479F & S SPECIAL STUDIES IN CIVIL ENGINEERING

IV – 1 (elective) 3 2 9

Students having the Departmental Chairman's approval, may undertake special studies of advanced topics that are not normally part of the undergraduate program.

CIV 498F THESIS

IV – 1 (elective) 3 2 9

With the approval of the Departmental Chairman, a Fourth Year student in Civil Engineering may undertake a 21-unit thesis instead of the usual 12-unit thesis (CIV 499S). Normally such theses will be experimental in nature and the topic must be submitted prior to the commencement of the fall term.

CIV 499S THESIS

IV – 1 – 6 12

All students in the Fourth Year of the Civil Engineering program must prepare a thesis on an approved subject. Topics are normally submitted for approval in the fall term with the work being done in the spring term under the supervision of a faculty member.

COMMERCE
(Department of Political Economy)

COM 390F ACCOUNTING I

III – 4 2 1 8

Accounting methods and principles; build-up of financial statements.

R. Peretz

COM 391S ACCOUNTING II

III – 4 2 1 8

Analysis and interpretation of financial statements; introduction to cost accounting and managerial accounting.

R. Peretz

DEPARTMENT OF COMPUTER SCIENCE

CSC 180F INTRODUCTION TO COMPUTER PROGRAMMING

I – 5 1 3 5

Introduction to algorithms and computer organization; FORTRAN or PL/I programming; programming numerical and non-numerical applications; simulation.

R. C. Holt, D. B. Wortman

CSC 280S COMPUTER LANGUAGES

II – 5 2 – 8

Definition of various programming languages including procedure-oriented, list processing, and simulation languages. Specification of syntax and semantics. Basic properties of programming languages. Introduction to formal languages and data structures.

J. N. P. Hume

CSC 380S SYSTEM SOFTWARE I

III – 5cs 2 6 10

Data structures as applied to assemblers and macroassemblers. Recognition of simple grammars. Input/output systems – data handling techniques as related to system hardware organization. The laboratory associated with this course will include assembly language programming.

E. S. Lee

CSC 390S INTRODUCTION TO THE THEORY OF COMPUTATION

III – 5cs 2 – 7

Introduction to formal logic – propositional and predicate calculus. Primitive recursive functions, computable functions, recursive functions, and recursive sets. Turing machines, unsolvable problems. Models, flowcharts, and program schemata; application to equivalence, termination, and correctness of programs.

J. Mylopoulos

CSC 448S AUTOMATA THEORY

IV – 5cs 2 1 7

Finite automata, sequential machines, regular sets, regular expressions, generative grammars, context-free grammars and push-down automata, context-sensitive grammars and linear-bounded automata, operations on languages, bounds for recognition, decision problems, unified theory of automata.

D. Tsichritzis

CSC 468S OPERATING SYSTEMS

IV – 5cs 2 1 7

Process control in computer systems, multiprogramming, generalized addressing, multiprocessing parallel computations. Protection schemes. Resource allocation, static and dynamic scheduling. Dynamic storage allocation, paging, memory management. Reliability-debugging tools, error tolerance.

D. Tsichritzis

CSC 480F SYSTEM SOFTWARE II

IV – 5cs 2 6 10

Compiler construction for high level languages; scanning techniques, symbol table techniques, table driven techniques, expression decoders, translator writing system techniques. System services with emphasis on their relation to computer system architecture. The laboratory associated with this course will consist of programming projects in IBM/360 Assembly language as well as various high level languages.

J. J. Horning

ELECTRICAL ENGINEERING

ELE 121S ELECTRICITY AND MAGNETISM

I – 1, 3, 4, 6, 7, 8, 9 3 2 10

A basic course in electricity and magnetism including electric forces and fields, analysis of direct-current circuits, magnetic forces and fields, electromagnetic induction, and an introduction to the conductive, magnetic and dielectric properties of materials.

ELE 150S ELECTRICITY AND MAGNETISM

I – 5 3 – 8

An introduction to electricity and magnetism adapted to the needs of Program 5. Elements of vector calculus. Coulomb's Law. Gauss's Law. Electric field of discrete and continuous charge distributions. Potential functions. Gradient and divergence. Laplace's equation. Method of images. Forces and energy. Capacitance. Forces on moving charges and conductors. Ampere's Law. Biot-Savart Law. Magnetic field of rings and coils. Faraday's Law and applications. Self- and mutual-inductance. Energy stored in a magnetic field. Alternating current circuits: series and parallel. Electric and magnetic fields in matter.

ELE 201S NUMERICAL METHODS

II – 7 2 2 7

Elementary numerical methods for systems of equations, iteration, integration, differential equations, roots and random number generation, including a study of roundoff and truncation error. Basic computer structure and organization. Algorithms, procedures, and flow charts. Discrete simulators and continuous simulators.

ELE 210F CIRCUIT THEORY I

II – 7 3 2 9

Circuits as models for physical devices; relationships between circuit and field concepts. Elementary network theorems and laws. Transient response of circuits. Topology and loop and nodal analysis. Response to complex frequency excitation. Steady-state response with direct and sinusoidal sources including analysis of polyphase circuits.

ELE 211S CIRCUIT THEORY II

II – 7 2 2 7

Complex frequency, network functions, and frequency response; resonance phenomena. Magnetically coupled circuits. General network theorems. Two-port networks. Fourier analysis.

ELE 221S ELECTRIC AND MAGNETIC FIELDS

II – 7 3 2 9½

Static electric and magnetic fields. Properties of dielectric and magnetic media. Particle dynamics in electric and magnetic fields. Time-varying fields. Development of Maxwell's equations and interpretation.

ELE 230F ELECTRICAL LABORATORY

II – 7 – 3 4½

Introduction to techniques of electrical measurement.

ELE 231S INTRODUCTORY ELECTRONICS

II – 7 2 3 9½

The broad application of semiconductor devices to common engineering systems; basic device characterization, modelling, amplification, waveshaping, switching.

ELE 235S THERMODYNAMICS AND STATISTICAL MECHANICS

II – 7 3 1 9

The fundamental principles of thermodynamics and statistical mechanics; Boltzmann, Fermi-Dirac and Bose-Einstein distributions and their applications to electric, magnetic and electromagnetic systems; elementary theory of fluctuations.

ELE 250F ELECTRIC CIRCUITS

II – 5 3 3 9

Circuit elements and Kirchhoff's laws; simple circuits. Transient response of circuits. Steady-state sinusoidal analysis. Coupled circuits. General network analysis: node and mesh methods, loop and cut-set methods, network theorems. Introduction to two-ports.

ELE 270F CIRCUIT THEORY AND MEASUREMENTS

II – 3 3 3 11

Introduction to linear circuits analysis. Phasor representation and the analysis of alternating current circuits in the steady state. Transducers for electical measurement of non-electrical variables, and associated instrumentation.

ELE 271S ELECTRICAL ENGINEERING

II – 4 (elective) 3 3 9

Analysis of single-phase and three-phase circuits; principles of ac and dc machines; introduction to vacuum-tube and solid-state devices; basis of digital computation and analogue simulation; electronic measurements applied to industrial processes.

ELE 272S ELECTROMECHANICAL ENERGY CONVERSION

II – 3 3 3 9

Principles of electromechanical energy conversion. Electromechanical systems. Actuators. Transient and steady-state operation of dc machines. Steady-state operation of ac machines.

ELE 300F APPLIED MATHEMATICS I

III – 7 3 2 9½

Theory of functions of complex variables, with applications. Partial differential equations.

ELE 301S APPLIED MATHEMATICS II

III – 7 2 2 6

Definition of probability and sample points; joint, conditional and independent probabilities. Random variables, distributions, densities and distribution functions. Functions of random variables, averages and moments. Estimation and sampling. Random processes; covariance and correlation.

ELE 310F SYSTEM & SIGNAL ANALYSIS I

III – 7 3 1 9

Representation of signals by orthogonal functions. Fourier series. Complex Fourier series. Fourier transform. Time-domain and frequency-domain convolution. Modulation. Laplace transform. Solution of linear differential equations using the Laplace transform. A study of the behaviour of continuous-time linear systems using transform and convolution methods. Transfer functions, frequency response, pole-zero configurations.

ELE 311S SYSTEM & SIGNAL ANALYSIS II

III – 7 2 2½ 7½

Discrete-time systems, Z transform. Introduction to feedback systems. Stability, root loci, Routh and Nyquist criteria of stability, Bode diagrams. Introduction to state-space system models.

ELE 312F ELECTROMECHANICAL ENERGY CONVERSION I

III – 7 2 2½ 8

Processes of electromechanical energy conversion; modelling and analysis of magnetic devices and systems; transformers and saturable reactors; commutator machines.

ELE 313S ELECTROMECHANICAL ENERGY CONVERSION II

III – 7 2 2½ 7½

Generalized polyphase machines; induction and synchronous machines; introduction to the control of electric machine systems.

ELE 320F FIELDS AND WAVES

III – 7 2 2½ 8

Propagation of plane waves. Reflection of waves at plane boundaries. Guided waves. Transmission line theory. Smith chart. Radiation from antennas. Diffraction and scattering. Introduction to holography.

ELE 331S ELECTRONIC CIRCUITS I

III – 7 2 3 8

P-N junction diode models; advanced applications of p-n junction diodes. Temperature dependence of diode characteristics and methods for compensation. Amplifiers, specifications, general methods of design. Field-effect transistors: characteristics, biasing, amplifiers, voltage controlled resistance. Bipolar transistors: basic concepts, fabrication, power gain, basic configurations, Ebers and Moll model, circuit models, single and multistage amplifiers. Switching properties, feedback amplifiers, oscillators. Narrow and wide band amplifiers. Power amplifiers. Integrated circuit design techniques.

ELE 335F PHYSICAL ELECTRONICS I

III – 7 2 1½ 7½

The prime objective of courses 335F and 336S is to provide a sound physical understanding of phenomena and devices in modern electronics. Circuit models of devices are developed from the mathematical models which describe the basic device physics. Band theory of solids: Fermi-Dirac statistics. Metals, semiconductors and insulators; thermionic emission, Schottky effect and high field emission with examples. Contact potentials. Semiconductor theory: band structure of Ge, Si and III-V compound semiconductors. Intrinsic and extrinsic semiconductors: general calculation of the Fermi level, hole and electron densities. Mobility, conductivity and their temperature dependence. Diffusion. The continuity equation and its solution. Theory of pn junctions; minority carrier injection, basic equations. Depletion and diffusion capacitances. Circuit models. Other diode structures: tunnel diodes, Schottky barrier diodes, Gunn diode.

ELE 336S PHYSICAL ELECTRONICS II

III – 7 2 1½ 6½

Unipolar transistors: basic types: junction-gate, M.I.S., and thin-film F.E.T.'s theory, circuit models. Bipolar transistors: fundamental theory, injection efficiency, base transport efficiency, small-signal low-frequency models. Charge storage models. High-frequency, small-signal analysis and circuit models. Fundamentals of integrated circuits: fabrication theory and technology: diffusion, epitaxy, oxide masking; capacitors, resistors, bipolar and unipolar transistor integration. Examples. Photoelectronics solid-state optoelectronic phenomena: photoconductive, photovoltaic and pn junction radiation detection. Vacuum photoelectronics: image orthicon, vidicon, image storage and intensification.

ELE 350F PHYSICAL ELECTRONICS I

III – 5cs, 5e, 5p 2 1½ 7½

Course 350F and 351S deal with the basic physics underlying the operation of semiconductor devices. Band theory of solids, metals, semiconductors, insulators, mobility and conductivity. Drift and diffusion currents. Theory of pn junctions. Tunnel and avalanche diodes. Bipolar transistors.

ELE 351F INTRODUCTORY ELECTRONICS

III – 5cs, 5e, 5p 2 1½ 7½

A communication system, an analog computer and a digital computer, as examples of electronic systems. Identification of basic circuit functions. Passive RLC circuits as load and coupling circuits in both the time domain and the frequency domain. Ideal active elements: Amplifiers, operational amplifiers, controlled sources, logic elements and memory elements. Nonideal behaviour of amplifiers and their classification. Ideal and real diodes and other applications. Qualitative description of pn junctions. Characteristics of bipolar transistors in the normal mode. Biasing of single transistor circuits. Derivation of 1st order equivalent circuits. Simple one transistor amplifier circuits.

ELE 352S PHYSICAL ELECTRONICS II

III – 5e, 5p 2 1½ 7

Recombination-generation processes. Further properties of the bipolar transistor. Junction field effect transistors; MOS transistors. Fundamentals of integrated circuits. Photoconductivity. Solid State optoelectronic phenomena. Vacuum photoelectronics: image orthicon, vidicon.

ELE 353F COMPUTER ORGANIZATION

III – 5cs 3 2½ 10

Digital System Principles, Registers and data flow. Computer structure, machine language instruction execution and sequencing, addressing techniques. Digital representation of data. Arithmetic operations. Memory hierarchy, direct and associative addressing. I/O techniques and channels. Some case studies of actual machines. Introduction to reliability.

The laboratory will include simulation studies of systems using GPSS, experiments involving logic systems and small computers, and problems.

ELE 354S ELECTRONIC CIRCUITS I

III – 5cs 3 1½ 8
III – 5e 3 3 11

AC coupled transistor stages. DC amplifiers. Integrated circuit design limitation. Multitransistor circuits from configuration point of view. Hybrid Π equivalent circuit models. Augio amplifiers. Wideband amplifiers. Tuned amplifiers, Negative feedback concepts and oscillators. Field effect devices and applications. Transistors as switching elements, simple logic and memory circuits.

ELE 355F SYSTEM AND SIGNAL ANALYSIS I

III – 5e 3 1 9
IV – 5cs, 5g 3 1 9

Vector spaces. Normed linear vector spaces. Banach and Hilbert spaces. Projection theorem. Approximation theory. Representation of signals by orthogonal functions; Fourier series, integral and transform. Modulation. Laplace transform. Z-transform. Block diagram manipulation. Study of the behaviour of continuous-time and discrete linear systems using transform and convolution methods. Applications.

ELE 356S SYSTEM AND SIGNAL ANALYSIS II

III – 5e, 5g (elective) 2 2½ 8

Modelling of physical systems. State representation of dynamic systems as vector matrix differential and difference equations. Linearization. Controllability and observability. Steady-state performance and stability analysis for constant, linear systems employing Bode diagrams, root loci, Routh and Nyquist criteria. Synthesis of elementary feedback compensators.

ELE 357F ELECTROMAGNETIC FIELDS

III – 5e, 5p (elective) 2 2½ 8

Wave propagation in linear electromagnetic media. Maxwell's equations and constitutive relations. Plane waves in dielectric and conducting media. Unbounded and bounded field system. Standing Waves. Wave Polarization. Poynting vector. Transmission lines. Smith Chart. Parallel-plane waveguide. Rectangular waveguide. Dielectric and optical waveguides. Elements of Integrated Optics. Retarded Potentials. Small loop and Short Dipole Antenna. Wave propagation in anisotropic media.

ELE 370F ELECTRONICS

III – 3 2 3 9

Principles of electronics. Linear models of electronic devices. Amplifiers, oscillation and filters. Electronic circuits.

ELE 371S ELECTROMECHANICAL ENERGY CONVERSION

III – 3 (1971–72 only), III – 5e (elective) 2 3 8

Principles of energy conversion. Transient operation of electromechanical systems. Electromechanical circuits. Rotating machinery.

ELE 400F APPLIED MATHEMATICS III

IV – 7 (elective) 2 1 7

Partial differential equations and the calculus of variations.

ELE 405F SWITCHING THEORY

IV – 7, 5e, III – 5cs (elective) 2 1 7

Boolean algebra, Boolean functions, combinational networks, minimum complexity combinational networks, Karnaugh and Quine-McCluskey minimization. Sequential machines state assignment, state reduction, relationship to switching components. The problems period will provide exercises in logic and sequential machine analysis and synthesis.

ELE 410F CONTROL SYSTEMS I

IV – 7 3 1½ 9

Open-loop and closed-loop control; feedback systems. Flow-graph analysis of complex systems. Steady-state performance analysis. Stability analysis for linear time-invariant systems; algebraic, real-frequency, and root-locus methods. Design of single input-output controls. Elementary nonlinear analysis.

ELE 411S CONTROL SYSTEMS II

IV – 7 (elective) 2 1½ 7

State representation of dynamic systems. Vector-matrix differential and difference equations as descriptions of linear systems. Eigenvalues, eigenvectors, and transition matrices. Controllability and observability. Introduction to optimization. Emphasis throughout on the use of analog and digital computers as aids to analysis and synthesis.

ELE 412F NETWORK THEORY

IV – 5e, 7 (elective) 2 1 7

Network analysis. One-port and two-port network parameters, and their relation to determinants of network equations. Natural frequencies. Transfer functions of two-ports. Interconnections of two-ports. Energy functions. Properties of network functions. Synthesis of LC, RC and RL one-ports. Positive real functions. Testing for positive realness. The Froster preamble. Brune realization. Brief treatment of Bott-Duffin and Miyata realizations. Properties of general passive two-port functions, balanced and unbalanced two-ports with and without magnetic coupling, and lossless two-port functions. Magnitude and angle functions. Minimum-phase and all-pass functions. Realization of lossless singly- and doubly-terminated two-ports.

ELE 413F POWER SYSTEM ANALYSIS

IV – 7 (elective) 2 1½ 7

Engineering criteria for generation, transmission and distribution of electrical energy in bulk. Characteristics of components and their significance to power system safety, reliability and economy. Behaviour of elementary power systems under normal and fault conditions.

ELE 414S POWER SYSTEM CONTROL

IV – 7 (elective) 2 1½ 7

Economic management of electric power system operation. Methods for determination of load flows. Economic scheduling of generating plants. Basic concepts of load frequency control. Analysis of power system dynamical performance including the effects of generator controls.

ELE 416S COMMUNICATION SYSTEMS

IV – 7 (elective) 2 3 7

Initial material amplifies the role and properties of the Fourier integral and the double sided Laplace transform as a means of describing communication signals and systems. Early attention is paid to the synthesis of desired input and output relationship by means of feedback circuits and by means of the transversal filter techniques.

The next topics are modulation and sampling, the convolution theorems, Nyquist (1928) band-limited signaling, sampling theory, and vestigial side band transmission. Elementary probability and statistical theory is introduced next to support the fundamental ideas of information theory, noise in electronic circuits, and random signals. Recommended Book: *Communication Theory Principles* by Charles W. McMullen.

ELE 419S ELECTROMECHANICAL ENERGY CONVERSION III

IV – 7 (elective) 2 1½ 7

The theory of linear passive power invariant transformations is developed. Electromagnetic devices will be presented by flux linkage models which are then modified by various generalized transformations in order to facilitate their representation in systems requiring transient and steady state stability studies. A generalized co-ordinate transformation system for an m-n phase system revolving with respect to any arbitrary reference frame is developed and this is then reduced to the more classical phase, dq, or symmetrical component models. Evaluation of system parameters required for the models will be discussed.

ELE 420F ELECTROMAGNETIC THEORY

IV – 7 (elective) 2 1 7

Wave polarization. Rectangular and circular waveguides. Uniqueness of solutions. Wave propagation in the ionosphere. Radiation from wire antennas, simple arrays and continuous current distributions. Fields and impedance of a current-carrying conductor. Concepts of impressed, induced and equivalent sources. Reciprocity. Calculation of self and mutual impedance.

ELE 421S RADIATION AND PROPAGATION

IV – 7 (elective) (prerequisite – ELE 420F) 2 1½ 7

Microwave amplifiers and oscillators. Microwave components. Antenna arrays. Microwave communication systems. Formal solution of boundary value problems; Green's functions. Scattering by conductors. Diffraction by apertures. Fourier optics and holography. Spherical-earth propagation.

ELE 430F ELECTRONIC CIRCUITS II

IV – 7 2 3 8

Design of semiconductor circuits emphasizing bias stabilization, feedback d-c amplifiers, broadband amplifiers, tuned amplifiers and large signal applications.

ELE 431S INTEGRATED CIRCUITS

IV – 5e, 7 (elective) 2 1½ 7

Design of integrated circuits with particular emphasis on the interaction between device and circuit design. Thin film and semiconductor integrated circuits. Design of integrated circuit components: capacitors, resistors, inductors, diodes, transistors. Linear and digital integrated circuit design techniques and limitations.
NOTE: An elementary knowledge of semiconductor physics will be assumed.

ELE 432S SWITCHING CIRCUITS

IV – 5cs, 5e, 7 (elective) 2 1½ 6

Large signal modelling of nonlinear circuits elements; analysis of static and transient circuit behaviour; use of time-domain circuit simulation. Design to specification with imperfect components – worst case and statistical approaches to reliable design. Application to solid state switches, multivibrators and networks of cascaded gate circuits. Signal transmission methods. Integrated circuit technology. Physical phenomena applicable to memory functions – ferromagnetics, cryogenics, electrostatics, photochromics, acoustics. Address selection principles. Universal requirement for high-current switches and sense amplifier design. Techniques for improving signal-to-noise performance.
NOTE: An elementary knowledge of switching theory will be assumed. This may be obtained from Course ELE 405A – Switching Theory, or by self study.

ELE 433S POWER SEMICONDUCTOR CIRCUITS

IV – 7 (elective) 2 1½ 7

Principles of thyristor devices. Study of inverter, converter and rectifier circuits with particular applications to DC and AC motor speed control and frequency conversion.

ELE 435F SEMICONDUCTOR PHYSICS

IV – 5e, 7 (elective) 2 1½ 7

Selected topics in important physical concepts, allied to a deeper understanding of the properties of semiconductors, comprising: Crystal structure and crystal binding. Elastic waves. Phonons and lattice vibrations. Thermal properties. Theory of metals.

Band theory applied to semiconductors. Semiconductor carrier concentrations and transport.

ELE 436F QUANTUM PHYSICS

IV – 7 (elective) 2 1½ 7

Development of Schroedinger equation and its application to simple models of atomic systems. Zeeman effect, angular momentum and electronic spin. Pauli principle and electron theory of atomic structure.

ELE 437S QUANTUM ELECTRONICS

IV – 5e, 7 (elective) (Prerequisite ELE 436F) 2 1 7

Theory of radiation absorption and emission; susceptibility, population inversion and maser action. Maser and laser materials and device properties, limitations and use of the devices; nonlinear behaviour of materials at optical frequencies.

ELE 440F COMPUTER PROGRAMMING & DATA STRUCTURES

IV – 5e, 7 (elective) 2 1 7

Number representation: binary number system, representation of negative numbers, binary arithmetic. Computer architecture: basic hardware structure, registers, memory system, addressing, instructions, I/O. Programming languages; machine language programming, basic and macro assemblers, compliers. Programming systems: data structures, properties of data types, syntax structures, parsing, symbol tables. The problems period will include exercises in programming in 360 assembly language.

ELE 441S COMPUTER ORGANIZATION & PROGRAMMING

IV – 5e, 7 (elective) (Prerequisite ELE 440F) 2 1 7

Computer organization: register implementations, register transfers, memory, control unit logic, instruction processing logic, execution unit, simple implementations of arithmetic operations. Programming languages; compilers (PL/1, Algol). Introduction to formal languages and machines. The laboratory session will include programming problems based on the course.

ELE 445S BIOMEDICAL ENGINEERING

IV – 5e, 7 (elective) 2 1½ 7

An introduction to some aspects of the interaction between engineering and medicine, given by the staff of the Institute of Bio-Medical Electronics and Engineering: Basic Anatomy and Physiology; Biological communication processes; Biological feedback and control; Bio-medical instrumentation; Cardiovascular measurements; Radiation diagnosis. The course is accompanied by laboratory experiments.

ELE 446S ACOUSTICS

IV – 7 (elective) 2 1½ 7

The physical and psychological nature of sound. The production, detection, and measurement of physical sound. Relationships between physical sound signals and psychological experiences. The behaviour of sound outdoors and indoors. Engineering criteria for noise and vibration. Tests, standards, and codes. Noise control methods.

ELE 447S ILLUMINATION

IV – 7 (elective) 2 1½ 7

The course deals in general with the engineering problems which relate to the effective use of light (physical, physiological and psychological) in the everyday life of man. The topics covered include: The nature and characteristics of light; The production of light: incandescence and luminescence; The human eye, visual processes, and visual phenomena; Radiometric and photometric units and laws; Photometric measurements; Calculation of photometric quantities; Design of the visual environment: principles which relate to visual comfort and efficiency; Colour and colorimetry; Light sources – circuits and controls; Visual problems at low light levels e.g. street lighting. The laboratory supplements the theoretical material of the lecture course.

ELE 450F CONTROL SYSTEMS I

IV – 5e (elective) 2 1½ 7

State representation of dynamic systems as vector-matrix differential and difference equations. Linearization. Controllability and observability.

Steady-state performance and stability analysis for constant-parameter linear systems. Synthesis of linear compensators by algebraic, frequency and root-locus methods. State-variable feedback compensation. Elementary nonlinear analysis and feedback control synthesis.

ELE 451S INTRODUCTION TO OPTIMAL CONTROL

IV – 5e (elective) 2 – 7

An introduction to the calculus of variations, the maximum principle and dynamic programming, as they apply to the optimal control of systems. Introduction to computational methods of optimization.

ELE 452F ELECTRONIC CIRCUITS II

IV – 5e (elective) 2 3 8

Design of electronic circuits. Multistage amplifiers. Feedback amplifiers. Oscillators. DC amplifiers. Wideband amplifiers. Tuned amplifiers. Mixers. Detectors. Active filters. Negative impedance converters. Gyrators. Introduction to computer design of electronic circuits.

ELE 453F COMMUNICATIONS PRINCIPLES I

IV – 5cs, 5e (elective) 2 1 7

Probability theory, probabilistic formulation of the communication problem, representation of physical communication channels, Gaussian noise process, power spectrum, correlation function, vector model of a communication channel, error rate estimates, channel capacity theorem, analogue conversion techniques, coding for transmission in noise. Textbook: *Principles of Communication Engineering* – Wozencraft and Jacobs.

ELE 454S COMMUNICATIONS PRINCIPLES II

IV – 5e (elective) 2 3 8

A study of the transmission and processing of digital information: Information sources; exponential error bounds and capacity theorems for coding and waveform channels; block and convolutional coding.

ELE 455F TECHNIQUES OF OPTIMIZATION

IV – 5cs 3 2 10

Linear and non-linear mathematical programming; dynamic programming; queuing theory; some problems in control theory; Monte Carlo methods. Applications will be drawn from engineering practice.

ELE 456F MICROWAVE SYSTEMS

IV – 5e (elective) 2 1½ 7

Guided wave theory. Coaxial, stripline and microstrip transmission lines. Elements of microwave integrated circuits. Variational and conformal mapping techniques for determining propagation characteristics of transmission lines. Inhomogenously filled waveguides. Discontinuities in waveguides. Periodic structures. Microwave systems components. Non-reciprocal microwave devices. Microwave sources. Radiation. Antenna fundamentals. Antenna arrays. Holography.

ELE 457S MICROWAVE ELECTRONICS

IV – 5e (elective) (Prerequisite ELE 420F or equivalent) 2 1½ 7

Stability criteria for active electromagnetic systems. Wave Interaction in active media: Gunn diodes, IMPATT diode, Solid state lasers, etc. Coupled systems: travelling wave tube, backward wave oscillator, acousto-electric amplifiers. Parametric interactions: Manley-Rowe relations, design of parametric amplifiers and harmonic generators. Microwave magnetics: isolator, circulator. Microwave Acoustics: acousto-optic modulator. Passive components: resonators, couplers, and hybrid circuits. Laboratory experiments are associated with each of the above topics.

ELE 470F ELECTRICAL SYSTEMS

IV – 8 2 3 9

Electrical heating and melting. High temperature and vacuum applications. Controls. Instrumentation. Sensors. Transducers. Automation. Feedback. Logic circuits and computers.

ELE 499 THESIS

IV – 7

Each student in Electrical Engineering is required to write a thesis on an approved topic of his choice. This may involve experimental or other project related activities. Further details are available from the Electrical Engineering Enquiry Office, G 146.

DEPARTMENT OF GEOLOGY

GLG 120F PRINCIPLES OF PHYSICAL GEOLOGY

II – 9, III – 5g 2 3 9

Principles of physical geology and the evolution of the earth as a planet. The origin of the earth and the physical processes that operate on and in it. One field trip.

J. B. Currie

GLG 122S PRINCIPLES OF HISTORICAL GEOLOGY

II – 9, III – 5g (Prerequisite GLG 180S or 120F) 2 3 9

A lecture-laboratory course that traces the history of the earth and its changing environments from the sequence of physical and biological events revealed in the rock record. Paleontology and concepts of geologic environments and time are emphasized in the laboratory and in the field.

G. Norris

GLG 180S APPLIED PHYSICAL GEOLOGY

I – 1, 3, 4, 5, 6, 7, 8, 9 (elective) 3 1½ 10

Fundamentals of physical geology as related to engineering problems and practice. Configuration of the planet and the effects of external and internal processes that act upon it; influence of earth processes as a factor in the design of engineering structures. Students will gain a knowledge of earth materials – their occurrence and uses.

S. D. Scott

GLG 220 MINERALOGY

II – 9 2 4 10, 2 4 10

A first course in mineralogy and crystallography; the study of minerals as inorganic chemicals in the earth's crust; the use of crystal chemistry to explain optical, morphological and other physical properties of minerals; the formation, occurrence and classification of minerals and their identification both micro- and macroscopically.

D. H. Gorman, J. C. Rucklidge

GLG 221S GEOLOGICAL DATA PROCESSING BY COMPUTER

II – 9 (elective) 1 3 8

Applied mathematics, probability and statistics for processing geological data using computer methods.

F. G. Smith

GLG 280S APPLIED PHYSICAL GEOLOGY

II – 1 3 1½ 8

A course similar to GLG 180S, but with alternate laboratory assignments.

GLG 320 PETROLOGY

III – 9 2 3 9, 2 3 9

The principles of petrology; the classification, description and interpretation of the sedimentary, igneous and metamorphic rocks. Microscopic petrography. Field work in first week of a 14-day field camp in the Tweed area immediately following the annual Third Year examinations.

J. J. Fawcett

GLG 321F STRATIGRAPHY AND SEDIMENTATION

III – 9 2 2 9

The properties and classification of sediments and strata. Sedimentary environments and tectono-environmental concepts in stratigraphy; the influence of global tectonics on local stratigraphy. An 8-day field camp immediately following the annual Second Year examinations.

F. W. Beales

GLG 322 TECTONICS

III – 9 1 3 9, 1 3 9

Geometry of existing deformational structures in the earth's crust and reconstruction of their mechanical development. Field work in second week of a 14-day Field camp in the Tweed area immediately following the annual Third Year examinations.

W. M. Schwerdtner

GLG 324 PHYSICAL GEOCHEMISTRY

III – 9 3 – 9, 3 – 9

Chemical thermodynamics, phase diagrams, electrochemistry, solution chemistry and ionic equilibria, kinetics with examples from natural and experimental mineral systems at a wide range of temperatures and pressures.

S. D. Scott, G. M. Anderson

GLG 327S GEOLOGY OF THE CANADIAN SHIELD

III – 9 (prerequisite GLG 321F) 2 2 9

The stratigraphy, tectonic divisions and economic aspects of the Precambrian. Laboratory study of geological maps and reports; examination of typical rock suites in hand specimens and thin sections.

A. M. Goodwin

GLG 421 MINERAL DEPOSITS

IV – 9 239, 239

Systematic mineralogy and phase equilibria of ore minerals. Identification of ore minerals in polished section. Geochemistry of ore-forming processes. Description of important ore deposits and discussion of their genesis.

A. J. Naldrett

GLG 422 EXPLORATION GEOCHEMISTRY

IV – 9 239, 239

Geochemical and geological aspects of mineral exploration, including characterization of target, nature of detectable halos surrounding target, typical survey methods and chemical analysis of materials obtained, statistical evaluation of data and elementary decision-making techniques.

S. E. Kesler, J. C. Van Loon

GLG 428F PETROLEUM GEOLOGY

IV – 9 239

Geological conditions of oil and gas entrapment within sedimentary basins. The occurrence of petroleum and natural gas pools. Exploration for energy resources.

J. B. Currie

GLG 429S GEOHYDROLOGY

IV – 9 (elective) 236

Groundwater as an element of the hydrologic cycle; its relation to the geology of a basin and to water resources management. Groundwater distribution in Canada. Mechanics of groundwater flow; methods of investigation and exploitation.

J. B. Currie, V. Klemes

GLG 499S THESIS

IV – 9 – 69

Each student is required to prepare a thesis on an approved subject. Instructions will be issued by the Chairman of the Geological Engineering Course Committee.

DEPARTMENT OF INDUSTRIAL ENGINEERING

IND 200F ELEMENTS OF INDUSTRIAL ENGINEERING I

II – 4 217

History of Industrial Engineering, nature of modern Industrial Engineering, mathematical models of systems as a central concept of the discipline, consequences for curriculum design. Examples of case histories to illustrate idea of mathematical models of systems. Some models of wide applicability – linear programming and stochastic models with illustrations of their use in production and inventory models and in resource allocation.

B. Bernholtz

IND 201S ELEMENTS OF INDUSTRIAL ENGINEERING II

II – 4 217

A broad survey of the principles of productivity management including methods study and work simplification, plant location and facilities planning, value analysis, work measurement, production and inventory control, quality control, resources management and organization theories.

J. Vanderheyden

IND 202F COMPUTERS AND PROGRAMMING I

II – 4 229

Coding and programming for the digital computer; machine organization, machine language and symbolic compiler language (PL/1); number representation and conversion. Laboratory exercises are drawn from the fields of engineering and applied science, as well as from those of data processing and elementary compilation.

G. R. Comrie

IND 301F OPERATIONAL RESEARCH I

III – 4 229

An introduction, using simplified case studies, to the methodology, techniques and applications of operational research.

A. A. Cunningham

IND 302S OPERATIONAL RESEARCH II

III – 4 229

Continuation of IND 301F, with greater emphasis on mathematical techniques.

A. A. Cunningham

IND 303F COMPUTERS AND PROGRAMMING II

III – 4 229

An extension of the Second Year subject Computers and Programming I. More advanced discussion of general and specialized compiler languages and their application in business, engineering and other fields; simulation, data processing, and list processor languages; Monte Carlo methods, GPSS, SIMSCRIPT, COBOL, etc. Laboratory problems are selected to complement the lecture material.

R. W. P. Anderson & S. H. Cohn

IND 304F INDUSTRIAL RELATIONS

III – 4 218

A discussion of trade unions, labour legislation and the collective bargaining process.

A. Kruger

IND 331S OPERATIONAL RESEARCH

III – 5cs, IV – 5cs, IV 5e (elective) 2 2 7

Processes of model building and solution. Problems of reliability, allocation, queueing, competition, sequencing, and co-ordination. Mathematical techniques of linear and dynamic programming, branch and bound methods, simulation, activity networks, and Markov processes.

J. G. C. Templeton

IND 401F INDUSTRIAL ENGINEERING SEMINAR

IV – 4 2 – 2

Members of the staff in Industrial Engineering and invited speakers prominent in the academic, governmental, and business communities will conduct a series of talks followed by general discussion.

IND 407F STATE SPACE METHODS IN PROCESS CONTROL

IV – 4 2 1½ 8

Short survey of systems engineering. State space representation of continuous and discrete-time systems. Solution of state space equations. Controllability and observability. Stability. Measures of system performance. Time-dependent parameters. Nonlinear processes. Stochastic processes. Business, engineering and socioeconomic applications.

J. M. Tusiewicz

IND 408S OPTIMAL CONTROL OF PROCESSES

IV – 4 2 1½ 8

Short survey of systems engineering. Goals and decisions; philosophical issues of value judgements. Computer process control. Steady-state process optimization. Well-defined process. Search techniques. Geometric programming. Adaptive control. Evolutionary optimization. Dynamic process optimization. Calculus of Variations. The maximum principle. Dynamic programming. Business, engineering and socioeconomic applications.

J. M. Tusiewicz

IND 409F MAN AS A MACHINE

IV – 4 2 – 8

Anatomical, Physiological, Bio-Chemical, Bio-Physical factors underlying the structural design of man's working environment.

P. J. Foley

IND 410S MAN AS AN INFORMATION PROCESSOR

IV – 4 2 – 8

Psychological factors underlying the functional design of man-machine systems.

P. J. Foley

IND 411F MAN AS AN INDIVIDUAL

IV – 4 2 – 8

The study of individual differences in intelligence, achievement, aptitude and personality, as well as differences related to sex, age, racial and cultural factors. Problems and methods of measurement.

J. L. Vitalis

IND 412S ORGANIZATIONAL BEHAVIOUR

IV – 4 2 – 8

Individual and group behaviour in work organizations. Relevance to human behaviour and management problems, supervision, communications, motivation and the implementation of change.

E. L. Vitalis

IND 413F FUNDAMENTALS OF MANAGEMENT SCIENCE

IV – 4 2 1½ 8

The course presents the basic principles of decision-making. It includes such concepts as the expression of individual choice by indifference curves, the analysis of data by Bayesian inference, the value of accurate information, and the use of cardinal utility to represent aversion to risk. The concepts are illustrated with industrial applications.

T. A. Lambe

IND 414S APPLICATIONS OF MANAGEMENT SCIENCE

IV – 4 2 1½ 8

Algebraic procedures are presented for applying decision theory to processes where uncertainty is characterized by multinomial, normal and Poisson distributions. Examples include inspection sampling, equipment replacement and marketing.

T. A. Lambe

IND 415F PRODUCTION SYSTEMS

IV – 4 2 1½ 8

Introduction to basic features of production systems and methods of modelling their operation.

J. A. Buzacott

IND 416S ADVANCED INDUSTRIAL ENGINEERING

IV – 4 2 1½ 8

Methods of design, operation and control of systems of men and machines.

I. B. Turksen

IND 417F STOCHASTIC MODELS

IV – 4 2 1½ 8

A course on the analysis of stochastic models in operational research. Review of relevant aspects of probability theory; Poisson processes and renewal processes; queueing models and Markov Chains; applications to problems in electronic testing, traffic flows, reliability, inventory, etc.

M. J. M. Posner

IND 418F SYSTEM SIMULATION

IV – 4 2 1½ 8

Computer simulation models. The theory will be developed and applied to problems in the design and analysis of queueing, inventory, maintenance, reliability, transportation, and resource allocation systems.

I. B. Turksen

IND 419S INFORMATION AND OPTIMIZATION

IV – 4 2 1½ 8

Introduction to information theory; topics in optimization theory.

J. G. C. Templeton

IND 420S MATHEMATICAL PROGRAMMING

IV – 4 2 1½ 8

Formulation of the linear programming problem, the simplex method (review), the revised simplex method, duality and the dual simplex method, postoptimality problems, parametric linear programming. Transportation problems, the fixed charge problem. Flows in networks. Integer linear programming, algorithms for the all-integer and the mixed integer-continuous problem. Fractional linear programming. Nonlinear programming. The Lagrangian function and its saddle points, Kuhn-Tucker theorem. Quadratic programming.

J. Abrham

IND 421S MANAGEMENT INFORMATION SYSTEMS

IV – 4 2 1½ 8

Study of information systems in relation to both operational and decision-making activities in an organization; special attention to management planning and control activities. Models of information systems; manpower, logistics, and financial subsystems. Integrated systems. The roles of the information analyst and systems designer; the information processing organization; user implications. The development cycle of information processing systems; project control, implementation, and evaluation; equipment selection and configuration; file structures and software. Terminal-oriented systems. Case study projects.

S. H. Cohn

IND 431F OPERATIONAL RESEARCH I

IV – 8 (elective) 2 2 8

An introduction to operational research methodology, techniques and applications.

Development of models and applications in the following areas are pursued: linear programming; graphs and networks; critical path analysis; dynamic programming.

R. W. P. Anderson

IND 432S OPERATIONAL RESEARCH II

IV – 8 (elective) 2 2 8

A continuation of subject IND 431F in which queueing theory, inventory theory, stochastic processes and simulation are discussed.

R. W. P. Anderson

IND 497F & S TERM THESIS

IV – 4 – 3 8

Application of the methods and models studies in other Industrial Engineering subjects to an industrial engineering problem. The work will be carried out under the supervision of staff members. A written report is required.

Staff in Industrial Engineering

IND 498F THESIS

IV – 4 – 3 8

Design and analysis of an engineering system to satisfy specified objectives and requirements. This project, extending over two terms (see subject IND 499S), will provide the student with an opportunity to apply the knowledge and techniques of analysis acquired in his other Industrial Engineering subjects. The work will be carried out by students working in small groups, or individually, under the supervision of staff members. An extended end-of-term written progress report is required. (May not be combined with IND 497F or IND 497S.)

Staff in Industrial Engineering

IND 499S THESIS

IV – 4 – 3 8

Continuation of IND 498F. A written thesis is required. (May not be combined with IND 497F or IND 497S.)

Staff in Industrial Engineering

DEPARTMENT OF MATHEMATICS

MAT 180F MATHEMATICS I

I – 1, 3, 4, 6, 7, 8, 9 4 3 12

Calculus; limits, derivatives, integrals and their properties with applications, elementary functions. Basic concepts of linear algebra.

Staff in Mathematics and Staff in Engineering

MAT 181S MATHEMATICS II

I – 1, 3, 4, 6, 7, 8, 9 3 4 12

Vectors, matrices, linear systems, transformations, eigenvalues, linear programming, complex numbers. Applications of linear algebra and calculus.

Staff in Mathematics and Staff in Engineering

MAT 185S LINEAR ALGEBRA

I – 5 2 1 8

Vector spaces, matrices, linear transformations, eigenvalues, quadratic forms and quadratic surfaces.

P. Quinn, P. A. Sullivan

MAT 194F CALCULUS I

I – 5 3 2 11

Theory and applications of differential and integral calculus, continuous functions, mean value theorem, elementary functions.

D. K. Sen, L. T. Gardner

MAT 195S CALCULUS II

I – 5 2 1 8

Sequences, series, improper integrals, Taylor's theorem, differential equations, functions of several variables and partial derivatives.

D. K. Sen

MAT 280F CALCULUS AND DIFFERENTIAL EQUATIONS

II – 1, 6 3 2 9

Functions of several variables, partial differentiation, maximum and minimum problems, Taylor series, ordinary differential equations and systems.

P. J. Rooney, R. Luus

MAT 289S COMPLEX VARIABLES

II – 5 3 1 9

Complex plane analytic functions, Cauchy's theorem, Taylor and Laurent series, singularities, analytic continuation, contour integration, conformal mapping, and applications.

C. Davis

MAT 290F CALCULUS

II – 7 4 2 11

Functions of several variables, partial differentiation, maximum and minimum problems, Taylor series, multiple integrals, ordinary differential equations, introduction to partial differential equations.

P. Quinn

MAT 293F CALCULUS

II – 3, 4, 8, 9 2 2 8

Functions of several variables, partial differentiation, maximum and minimum problems, Taylor series.

D. Masson, J. Abrham, J. Corbett

MAT 294S CALCULUS AND DIFFERENTIAL EQUATIONS

II – 4, 8, 9 2 2 8

Ordinary differential equations and systems, multiple integrals, curve integrals.

D. Masson, J. Abrham, J. Corbett

MAT 295F CALCULUS III

II – 5 3 1 8

Convergence and uniform convergence, linear differential equations, co-ordinate transformations, multiple integrals, line and surface integrals, orthogonal functions.

C. Davis

MAT 389 THEORY OF FUNCTIONS

III – 5 2 – 5, 2 – 5

Complex numbers, limits and series, analytic functions, Cauchy's theorem, Taylor and Laurent series, singularities and their significance, analytic continuation, contour integration, conformal mapping of one plane region on another.

W. H. Greub

MAT 395 DIFFERENTIAL EQUATIONS

III – 5 2 – 5, 2 – 5

First order equations solvable by quadratures, the linear equation of general order, operator methods, simultaneous linear equations, Sturm-Liouville systems, numerical methods.

M. Heble

MECHANICAL ENGINEERING

MEC 201S DYNAMICS I

II – 3 3 1½

Calculus of vectors; kinematics of bodies in rectilinear and curvilinear translation rotation, and free motion; impulse, momentum and moment of linear momentum conservative systems; work-energy relations; dynamics of motion; Euler's equations gyroscopic mechanics; plane motion; D'Alembert's principle; virtual work and Bernoulli's principle; introduction to generalized co-ordinates, degrees of freedom, an Lagrange equations; introduction to mechanical vibrations and balancing.

R. C. Flanaga

MEC 205F DYNAMICS

II – 7 3 2 9

Dimensional units; vectors; kinematics, rectilinear and angular motion, plane motion, projectiles; satellite orbits, rigid body concept, relative motion with respect to translating and to rotating vehicles, force, d'Alembert's principle, rotation, translation, vibration of mechanical and electrical systems, work, energy, conservation of energy, power, impulse, momentum, rockets, jets, fluid mechanics, impact, balancing, centrifugal and Coriolis' force, critical speeds, gyroscopic effect. Reference Book: *Vector Mechanics for Engineers – Dynamics* – Beer & Johnston.

F. P. J. Rimrott

MEC 211F MECHANICS OF DEFORMABLE BODIES I

II – 3 3 3 10

Simple stress and strain; concept of stress and strain at a point with treatment in 2-D cases (plane stress and strain); principal stresses; Mohrs method; Yield criterion; fatigue; application to analysis of simple machine elements (beams, shafts, thin shells, joints, etc.); properties of mechanical engineering materials (ferrous and non-ferrous metals, polymers).

D. McCammond

MEC 212S MECHANICS OF DEFORMABLE BODIES II

II – 3 3 1½ 8

Generalized equilibrium and compatibility relationships with application to axially symmetrical problems (thick cylinders, rotating discs); theory of plates and shells; thermal stress analysis; energy methods; simple plasticity; experimental stress analysis methods.

MEC 261F DIFFERENTIAL EQUATIONS

II – 3 3 3 11

First order equations, second order equations, operator techniques, system of equations, power series for variable-coefficient equations, eigenvalue equations, numerical techniques.

F. P. J. Rimrott

MEC 302S DYNAMICS II

IV – 3 (elective) 3 1½ 10

Brief review of basic laws of classical Newtonian mechanics; Euler angles and gyrodynamics; generalized co-ordinates and their transformation; theorem of virtual work and D'Alembert's principle; kinetic and potential energy; dissipative power functions and Lagrange equations of motion; determination of constraint forces; variational dynamics; Hamilton's equations and principle; astronautics; orbital mechanics; rocket mechanics.

R. C. Flanagan

MEC 303F VIBRATIONS

III – 3 3 3 11

Analysis of single degree of freedom systems; Various types of damping forces; Vibration isolation; vibration measuring instruments; steady state and transient vibrations; vibration of multi-degree of freedom systems; numerical methods of frequency analysis; Lagrange equations and Hamilton's principle; energy methods; vibration of strings, beams, plates and torsion of shafts; approximate methods; introduction to non-linear vibrations; introduction to wave propagation in solids.

D. L. Allen

MEC 315S EXPERIMENTAL STRESS ANALYSIS

III – 5nt, 5p (elective) 3 – 8

The elementary concepts of the theory of elasticity will be given. The experimental techniques of measuring stress or strain will be studied; these techniques include strain-gauge, photoelastic, brittle-coating and moire methods.

G. E. Godfrey

MEC 321F THERMODYNAMICS

III – 3 3 3 11

Classical thermodynamic description of systems and processes; basic laws of thermodynamics; the Carnot argument, entropy, availability and criteria for equilibrium; nonreactive mixtures and ideal cycles.

F. C. Hooper

MEC 326S STATISTICAL THERMODYNAMICS

III – 5nt 3 – 9

A development of thermodynamics in which the ensemble approach is used to treat isolated, closed and open systems; to include such topics as the Liouville theorem, statistical equilibrium, partition functions, specific heats, and fluctuations in thermodynamic properties.

MEC 327S HEAT ENGINEERING

III – 5nt 2 3 8

This course consists of a study of the fundamental concepts of macroscopic thermodynamics, and their applications to closed and open dynamic systems. An examination of the principal power cycles is undertaken in relation to the properties of the working media involved. Emphasis is placed on a thorough understanding of the three basic laws of thermodynamics. Textbook: *Concepts of Thermodynamics* – Obert. Reference Books: *Engineering Thermodynamics* – Hall and Ibele. *Thermodynamics* – Van Wylen.

F. C. Hooper

MEC 341S FLUID MECHANICS I

III – 3 3 3 10

Introductory concepts; fluid properties, dimensional analysis; hydrostatics; kinematics and dynamics of flow; irrotational flow and vorticity; dynamic lift; laminar flow; turbulent flow; applications to closed conduit and open-channel flow; one-dimensional compressible flow.

H. J. Leutheusser

MEC 342S FLUID MECHANICS II

IV – 3 (elective) 3 1½ 10

Flow of an ideal fluid, complex variable analysis, lift, finite wing theory, viscous fluid flow, simple solutions of Navier-Stokes equations, lubrication theory, boundary-layer theory, drag of streamline bodies, turbulent flow, diffusion in turbulence, dynamics of submerged bodies, introduction to aeroelasticity, free surface phenomena.

J. F. Keffer

MEC 345F FLUID MECHANICS

III – 5nt 3 3 12

A fundamental approach to the mechanics of fluid motion; continuum concepts; kinematics and dynamics of flow, irrotational motion; vorticity; laminar flow solutions; turbulent motions; applications to conduit flow; thermodynamic relationships; elementary thermal transport; free surface waves; fluid machinery.

I. Currie

MEC 348S FLUID MECHANICS AND THERMODYNAMICS

III – 4 2 3 8

Fluid properties and equation of state, momentum and energy equations; dynamics of flow, laminar and turbulent flow, closed-conduit flow. Laws of thermodynamics, the Carnot cycle, real and ideal fluids, power cycles, psychrometry and heat transfer.

A. B. Allan, I. Currie

MEC 349S TRANSPORT PHENOMENA

III – 8 3 3 9

A study of the forces and motion produced by various fluid properties. Gravitational, viscous and inertial forces are considered in detail. Momentum, energy and continuity relation, boundary-layer approximation, turbulence, flow in pipes and around submerged bodies. Steady-state conduction in one dimension; extended surfaces; heat conduction with two or more independent variables; forced convection and dimensional analysis; heat transfer by free convection; radiant heat transfer; heat transfer by combined conduction and convection; heat transfer in liquid metals.

L. E. Jones, P. Shen

MEC 351F FLUID MECHANICS

III – 1 3 3 10

Properties of fluids, fluid statics, pipe-line flows, compressible flows, momentum and energy equations, dimensional analysis, free surface flows, flow around submerged bodies, turbulent flows, pumps, water hammer and surge tanks.

H. J. Leutheusser

MEC 357S CONTROL ENGINEERING

III – 4 2 2 8

An introduction to the dynamic behaviour of linear systems; the feedback principle; stability of linear control systems; the convolution theorem; transfer functions of linear systems; analysis of linear control systems; introduction to servo-mechanism technology. Problems and laboratory experiments will accompany the lectures.

J. S. Ansari

MEC 362F ENGINEERING ANALYSIS I

III – 3 3 3 11

Analytical techniques including vector analysis, complex variables and solution of differential equations by Laplace transforms.

V. Klemes

MEC 363S ENGINEERING ANALYSIS II

III – 3 3 1 8

Continuation of Engineering Analysis I. Solution of standard differential equations with variable coefficients, orthogonal functions, eigenfunction expansions, Fourier series, introduction to partial differential equations.

D. F. James

MEC 395S HEAT ENGINEERING

III – 3 2 3 8

Applications of thermodynamics to machines, including: background to the development of heat engines; basic steam power plant cycles and design; internal combustion engines and cycles; combustion calculations; fuel and exhaust products analysis; power plant testing; heat transmission; psychrometry and air conditioning.

A. B. Allan

MEC 397S ENGINEERING DESIGN

III – 3 2 3 8

Approach to engineering design; problem definition; generating and comparing concepts; synthesis-analysis-evaluation decisions under realistic situations. Engineering examples and small design projects utilizing available background of mathematics, mechanics, circuits and thermodynamics. Specific attention is given to such subjects as springs, curved beams and experimental stress analysis.

MEC 424F THERMAL POWER GENERATION

IV – 3 (elective) 3 1½ 10

Plants and processes in major power production; overall design and heat balance in steam plants; non-central power production; characteristics of portable power units and auxiliaries.

A. B. Allan

MEC 425S MICROSCOPIC THERMODYNAMICS

IV – 3 (elective) 3 1½ 10

The statistical approach to the treatment of real fluids and nonequilibrium systems; the Boltzmann equation and entropy; fluctuations about the equilibrium state and rate processes.

C. A. Ward

MEC 428F THERMAL ENERGY CONVERSION I

IV – 5nt 3 3 11

The thermodynamics and gas dynamics of thermal energy conversion. Steam power cycles, nuclear reactor and fossil fuel energy sources, magneto-hydrodynamics power generation, fuel cells, combustion, refrigeration, new trends and research developments.

D. S. Scott

MEC 429S THERMAL ENERGY CONVERSION II

IV – 5nt 3 3 11

Continuation of MEC 428F

D. S. Scott

MEC 431S HEAT AND MASS TRANSFER

IV – 3 3 3 10

Steady state and transient conduction, surface and gas radiation, convection, boiling, condensation and combined mechanisms of energy transport are considered, together with an introduction to mass transport; application of these topics in the design of heat transfer equipment.

A. Abdelmessih

MEC 433S HEAT TRANSFER

IV – 5nt 2 – 6

Steady state and transient conduction, surface and gas radiation, convection, boiling, condensation and combined mechanisms are considered. Special attention is given to analogue and computational procedures and to consideration of the manner in which novel or complex problems may be approached. Textbook: *Heat Transmission* – McAdams.

F. C. Hooper

MEC 443S APPLIED FLUID MECHANICS

IV – 3 3 3 10

Pipe, networks; one dimensional gas dynamics including simple area change, simple friction, simple heating, generalized flow and normal shock waves; hydraulic transients including surges and water hammer; flow machines; fluid power circuits; other topics of engineering significance. Problems and experiments in applied fluid mechanics.

W. D. Baines

MEC 452S HYDRAULIC ENGINEERING

IV – 1 (elective) 3 2 9

Review of flow principles. Techniques of field measurement. Open channel and closed-circuit flow. Hydraulic structures and appurtenances, transitions, controls; dams; navigation works; methods of construction. Hydraulic machinery, pumps, turbines, power and control systems. Design and testing of hydraulic engineering systems; analytical procedures, numerical methods and computer simulation. Systems analysis.

L. E. Jones

MEC 455F CONTROL SYSTEMS

IV – 3 3 3 11

Analysis and synthesis of linear feedback systems by frequency response methods and the rootlocus technique. Introductions to nonlinear control systems, the statespace technique, and digital computer control.

J. Vande Vegte

MEC 458S CONTROL SYSTEMS

IV – 5a, 5nt 3 3 11

Linear control systems by the transfer function technique and the state space approach. Elementary nonlinear control systems. Introduction to sampled-data and to digital control systems. Introduction to optimal control.

J. Vande Vegte

MEC 464F ENGINEERING ANALYSIS III

IV – 3 3 1½ 10

Partial differential equations in engineering including such topics as Fourier series and integrals, integral transforms, classification of partial differential equations, solutions of the Laplace, diffusion and wave equations.

I. G. Currie

MEC 473S SCIENCE OF DESIGN

IV – 3 (elective) 3 1½ 10

Programmed decision making; optimization methods; computer aided graphics; mathematical design models; design and production; value engineering; reliability; management of design.

R. C. Fenton

MEC 475F MANUFACTURING SCIENCE

IV – 3 (elective) 3 1½ 10

Study of standard production processes including casting, forging, cutting, etc.; mechanics and thermodynamics of chip removal; theory of plasticity applied to metal working, forming and extrusion; production processes related to properties of metals, plastics and composites; sintering; explosive forming; beamed radiation; numerical control of machines and systems.

R. C. Fenton

MEC 495S APPLIED ELASTICITY

IV – 3 3 1½ 9

Beams on elastic foundations, energy methods, torsion of non-circular cylinders and open sections, thick discs, composite cylinders, equations of two-dimensional elasticity, description of continuous media.

B. Tabarrok

MEC 499 THESIS

IV – 3

The student may choose a topic of his own preference from a list of topics prepared by the staff or he may use his own topic provided a staff member agrees to supervise the work. The thesis topic may be one of the following:

(i) an engineering design project
(ii) a research project
(iii) a state-of-the-art essay of an engineering problem

DEPARTMENT OF METALLURGY AND MATERIALS SCIENCE

MMS 100S STRUCTURE AND PROPERTIES OF MATTER

I – 1, 3, 4, 5, 6, 7, 8, 9 (elective) 3 1½ 10

An introduction to the structure and properties of the different states of matter in terms of the interatomic potential and thermal energy. A comparison of solids, liquids and gases, with special attention being directed towards crystalline solids. Specific topics considered include elasticity, viscosity, surface properties and capillarity, wave motion and the thermal and optical properties of matter. Textbook: *Gases, Liquids and Solids* – Tabor.

Staff in Metallurgy and Materials Science and Physics

MMS 201F STRUCTURE OF MATERIALS AND METALLOGRAPHY

II – 8 2 3 9

A course dealing with both the theoretical interpretation and the experimental determination of the structure of solids. Structure is discussed in terms of crystallography, defects in crystals, amorphous materials, polycrystalline grain structure and phase distribution in alloys. Metallographic techniques for the determination of microstructure by optical, x-ray, electron and field-ion microscopy are considered, as are quantitative metallography and the introductory principles of x-ray diffraction.

W. A. Miller

MMS 202F PHYSICAL CHEMISTRY I

II – 8 2 3 9

The physical-chemical properties of matter: ideal and real gases, liquids and solids, surface properties, viscous flow, and the concept of energy. Heat capacities and Debye's cubic law. Entropy and free energy for pure materials, order-disorder phenomena and configurational entropy. Introduction to solution properties and chemical equilibria. Ellingham diagrams and experimental methods.

S. N. Flengas

MMS 203S PHYSICAL CHEMISTRY II

II – 8, 9B 2 3 8

Phase diagram calculations – van't Hoff equations for the liquidus. Solid solubility under equilibrium conditions. Binary and ternary systems. Structure of liquids. Metallurgical systems such as the Fe-O, Fe-C and Fe-O-Si, are discussed in detail. Solubility of gases in liquid metals.

J. M. Toguri

MMS 204S METALLURGICAL CHEMISTRY

II – 8 2 5 10

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber cycle and replacement reactions. Point defects, non-stoichiometry and conductivity. The Schroedinger equation and its solution in terms of orbitals. Bonding in condensed phases. The laboratory deals with the instrumental analysis of ores, concentrates, slags and alloys.

C. B. Alcock, H. U. Ross

MMS 205S MATERIALS SCIENCE

II – 8 4 –

A course on the structure and properties of plastics, glass, ceramics, semi-conductors and concrete. (*Staff in Chemical Engineering, Civil Engineering, Electrical Engineering and Metallurgy and Materials Science*)

MMS 221F MATERIALS SCIENCE

II – 7 3 1½ 8½

The physical and chemical properties of materials will be related to their microscopic structure. Atomic bonding, crystal structure (with special emphasis on Group IV and Group III-V semiconductors): Thermodynamics of ideal and real solids. Solid-state diffusion. Phase diagrams, phase transformations with examples. Single crystal growth. Mechanical properties: stress, strain and shear relations for isotropic and anisotropic materials; annealing, structural materials; fabrication processing. Corrosion.

J. W. Rutter

MMS 222F MATERIALS SCIENCE

II – 4 (elective) 3 3 9

The effects of microscopic and atomic structures on the electrical, chemical and mechanical properties of engineering materials. The topics covered include atomic bonding, structures of ideal and real crystals, phase transformations and diffusion, chemical and mechanical properties, and oxidation and corrosion phenomena. The laboratory experiments will include x-ray studies of crystal structure; measurement of resistivity and magnetism of solids; studies of alloy phases and transformations; dislocation patterns, stress-strain relationships, stress-relaxation and fatigue phenomena; oxidation and corrosion reactions.

B. Ramaswami

MMS 223S MATERIALS SCIENCE

II – 3 3 3 8

The effects of microscopic and atomic structures on the properties of engineering materials. The topics covered include atomic bonding and structures of materials, diffusion, crystal growth and solidification, plastic deformation and annealing, precipitation hardening, phase transformations especially in ferrous materials, relationships between structures and mechanical properties of metallic and non-metallic materials, and composite materials. The laboratory experiments are designed to illustrate the principles underlying the relationship between structures and properties of engineering materials.

K. T. Aust

MMS 224S INTRODUCTORY METALLURGY

II – 9B 2 – 6

An introduction to the metallurgical processes used to extract metals from their ores and to refine and fabricate the final material into useful products. The course is designed around the flowsheets of processes for many of the most important metals.

H. U. Ross

MMS 225F PHYSICS AND CHEMISTRY OF MATERIALS

II – 9B 4 3 8

A course dealing with the structure of solids, liquids and gases. The physio-chemical properties of matter are considered from a thermodynamic viewpoint.

S. N. Flengas, W. A. Miller

MMS 226S INORGANIC CHEMISTRY

II – 9B 2 2 8

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber-cycle and replacement reactions. Point defects, non-stoichiometry and conductivity. The Schroedinger equation and its solution in terms of orbitals.

C. B. Alcock

MMS 301F MINERAL PROCESSING

III – 8 2 3 8

The theory and practice of minerals beneficiation including particle size measurement, comminution, sizing, liquid-solid separation and ore concentration. The course also includes the relevant aspects of mineralogy, surface chemistry and the movement of solid particles in liquid media.

H. U. Ross

MMS 302F THERMODYNAMICS

III – 8 2 4 1

A study of chemical equilibria at high temperatures in extractive metallurgy – slag metal reactions – classical theory of solutions – phase transformations – thermodynamic relationships in phase diagrams.

S. N. Flengas

MMS 303F PHYSICAL METALLURGY

III – 5m, 8 3 3 1

An introduction to the fundamental basis of microstructure control stressing th importance of alloying, plastic deformation and annealing. The principles of solidification, crystal growth, and phase transformations in solids are considered in detail.

U. M. Franklin, B. Ramaswami, J. W. Rutte

MMS 304S PHYSICS OF METALS

III – 5m, 8 3 3

Plastic deformation and mechanical properties are discussed in terms of dislocatio theory. The annealing processes of recovery, recrystallization and grain growth an the structure and properties of interfaces in materials are also considered.

K. T. Aust, W. A. Miller, B. Ramaswan

MMS 305S EXTRACTIVE METALLURGY

III – 8 4 3 10

A fundamental treatment of the pyrometallurgical processes involved in the production of the important non-ferrous metals, including oxidation of sulphides in the liquid and solid states, reduction of oxides and chlorides, matte-slag and metal-slag equilibria and kinetics and the distillation of metals. Experiments in materials processing, including roasting, smelting, leaching, refining, electrolysis. Eight laboratory reports per term.

C. B. Alcock, A. McLean, H. U. Ross

MMS 306F METALLURGICAL THERMODYNAMICS

III – 5m 3 4 12

A study of chemical equilibria at high temperatures in metallurgy; slag-metal reactions; chemical theory of solutions; alloys; phase transformations; thermodynamic relationships in phase diagrams; statistical concept of entropy; simple partition functions; quasichemical approach to the theory of solutions; methods of investigating thermodynamic properties.

S. N. Flengas

MMS 307S MATERIALS SCIENCE

III – 5m 3 – 8

A course dealing with the structure and properties of metals, alloys, glasses, and ceramics.

W. A. Miller, G. C. Weatherly

MMS 321S EXTRACTIVE METALLURGY

III – 9 3 – 6

The metallurgical processes involved in the beneficiation of ores and the extraction of metals therefrom and their subsequent refinement.

H. U. Ross

MMS 322S MATERIALS SCIENCE II

III – 7 2 1½ 6½

The magnetic, dielectric and conductive properties of materials, as related to their structure. Magnetic properties: dia-, para-, ferro-, antiferro-, and ferri-magnetic phenomena; magnetic domains and domain wall motion; "hard" and "soft" magnetic materials, magneto-striction. Dielectric materials: insulating properties; conduction mechanism; dielectric loss. Ferroelectric materials. Electrical conduction: temperature dependence; effect of composition and structure on conductivity. Thermoelectric phenomena.

U. M. Franklin

MMS 331F MATERIALS SCIENCE LABORATORY

III – 8 (elective) – 3 6

Projects in materials science, chosen by the student, and carried out in close consultation with a staff supervisor.

B. Ramaswami

MMS 332S EXTRACTIVE METALLURGY PROJECT

III – 8 (elective) – 3 6

A laboratory project in extractive metallurgy relating to course 305.

Staff in Metallurgy and Materials Science

MMS 401F EXTRACTIVE METALLURGY

IV – 8 2 4 9

The refining of metals at high temperatures, hydrometallurgical processes for extraction of metals and electrolytic refining.

C. B. Alcock, A. McLean, J. M. Toguri

MMS 402F PHYSICS OF METALS

IV – 5m, 8 3 4 10

Application of thermodynamics and kinetics to solid state phase transformations, theory of martensitic transformations, structures and properties of ferrous materials.

G. B. Craig, G. C. Weatherly

MMS 403S MATERIALS SCIENCE

IV – 8 3 1 8

Structures and properties of interfaces, recovery and recrystallization, annealing textures and anisotropic properties. Principles of solidification; growth of single crystals; casting processes.

K. T. Aust, J. W. Rutter

MMS 404S ELECTROCHEMICAL PROCESSES

IV – 8 2 2 8

Electrochemistry of solids, liquids, and of high temperature systems. Fused salt electrochemical cells. Thermodynamics of imperfections and properties of ionic solids.

S. N. Flengas

MMS 406S ADVANCED CHEMICAL METALLURGY

IV – 8 (elective) 1 3 7

Selected topics related to the behaviour of metallic, ceramic and metal-slag systems at high temperatures. Thermodynamic and transport properties of alloys and metallic oxides, carbides, silicides, etc. High temperature corrosion reactions and vaporization processes.

Staff in Metallurgy and Materials Science

MMS 407S METALLURGICAL SYSTEMS ANALYSIS

IV – 8 (elective) 2 1 7

The methods for evaluating metallurgical processes in terms of material resources and cost are considered together with the scientific factors which determine the choice of processes in order to obtain a synthesis of operational decision making.

Staff in Metallurgy and Materials Science

MMS 408S MATERIALS SCIENCE

IV – 5m 3 3 10

A continuation of course 307 with emphasis on physical and mechanical properties of materials; high-purity and composite materials. The laboratory work deals with experimental studies of the relationship between structures and properties of materials.

K. T. Aust, J. W. Rutter

MMS 409S HIGH TEMPERATURE PHYSICAL CHEMISTRY

IV – 5m 2 2 8

Properties of solids and liquids at high temperatures; Thermodynamics of defects; solid oxide electrolytes; mechanism of electrical conductivity in ceramic phases; fused-salt electrolytes; reactions in fused-salt media; electrochemical cells at high temperatures; fuel cells; structural properties of simple and complex liquid phases; electrochemical corrosion and passivation; kinetics of heterogeneous reactions.

S. N. Flengas

MMS 410F THEORY OF METALLURGICAL REACTIONS

IV – 5m 2 2 8

Metal extraction and refining processes are examined in terms of chemical thermodynamics and kinetics. The principles and methods of extraction of ferrous and non-ferrous metals, roasting, leaching and electro-winning are typical of the subjects discussed.

J. M. Toguri

MMS 431F POWDER METALLURGY

IV – 8 (elective) 2 – 6

Production and agglomeration of powders, the theory and practice of sintering, and the application of powder methods in the production of refractory metals, cemented carbides and other materials.

K. T. Aust, J. W. Rutter

MMS 432S PHYSICAL METALLURGY PROJECT

IV – 8 (elective) – 3 6

A laboratory project in ferrous physical metallurgy.

G. B. Craig

MMS 499 THESIS

IV – 8 — – 6 8, – 12 13

The student chooses an experimental problem involving original work, which normally is related closely to the current research of a staff member. The student is asked to prepare both a written report and an oral presentation describing the work. No laboratory time is specified for the engineering science (materials science option) thesis (APS 479) but the project is of essentially the same extent as that described above.

Staff in Metallurgy and Materials Science

DEPARTMENT OF PHYSICS

PHY 180F ELEMENTS OF PHYSICS I (MECHANICS)

I – 5 — 2 2½ 9

Introduction to atomic and nuclear physics. Addition and multiplication of vectors with physical applications. Trajectories of particles. Rotational motion, conservation of angular momentum, moments of inertia, gyroscopes. Non-uniform accelerations, simple harmonic motion. Reaction kinematics. Philosophy of conservation laws and symmetries. Gravitational and other natural forces.

K. G. McNeill

PHY 181S ELEMENTS OF PHYSICS II (THERMODYNAMICS AND STATISTICAL PHYSICS)

I – 5 — 2 2½ 9

Heat and thermodynamics, the laws of thermodynamics with physical applications. Ideal gases, kinetic theory, Maxwell-Boltzmann distribution of molecular velocities, specific heats of monatomic and polyatomic gases. Basic probability notions, postulates of statistical physics, entropy, absolute temperature, the canonical distribution. Crystalline symmetry, elastic behaviour of solids. Dynamics of crystalline lattices, specific heats and solids, heat conductivity, thermal expansion.

D. G. Ivey

PHY 224S PHYSICS OF SOLIDS AND FLUIDS

III – 5g, 5p — 2 – 6

Cartesian tensors and the properties of non-isotropic solids. Problems in elasticity, thermoelasticity, piezoelasticity, heat conduction. Hydrodynamics, ideal and viscous flows and a general discussion of the Navier-Stokes equations.

J. V. Iribarne

PHY 225F GEOPHYSICS

III – 5g — 2 1 6

Physics of the earth, its atmosphere, magnetosphere; its evolution and processes taking place on it. An outline of the methods utilized in attacking current research problems is presented.

R. List, G. Garland

PHY 280F ELEMENTS OF PHYSICS III (FIELDS AND WAVES)

II – 5 3 2½ 9

Principle of relativity, Lorentz transformation, Einstein's special relativity, relativistic dynamics, space-time geometry, the electromagnetic field, analysis of a vector field. Matter in electrostatic and magnetostatic fields, electromagnetic field of uniformly moving charges, Maxwell's equations, radiation and its detection. Interference of electromagnetic waves, Huygen's principle and diffraction. Maxwell's equations in the presence of matter.

D. G. Ivey

PHY 281S ELEMENTS OF PHYSICS IV (QUANTUM PHYSICS)

II – 5 2 2½ 8

Classical systems and quantum systems. Wave-particle duality, Heisenberg uncertainty principle, electron and nuclear spin. Schroedinger equation. Eigenvalues and eigenfunctions. Transition probabilities. The harmonic oscillator. The hydrogen atom. Quantum aspect of electromagnetic radiation, quantum electrodynamics. Nuclear interactions, stable and unstable nuclei. Elementary particles – their production and interactions.

T. Drake

PHY 282F INTRODUCTION TO MODERN PHYSICS

II – 8, 9B 3 1 7

Quantum Mechanics. Statistical Mechanics. Atomic and Nuclear Structure. The Solid State. The Interaction of Electromagnetic Radiation and Matter.

T. Drake

PHY 283F BASIC CLASSICAL AND MODERN PHYSICS

II – 9 3 – 8

A review of dynamics emphasizing the energy-momentum point of view and conservative systems; oscillatory and wave motion; an introduction to continuum mechanics and tensors; thermal physics including free energies and entropy; an introduction to quantum phenomena; basic explanations for the thermal, deformational and electrical properties of materials.

R. Desai

PHY 284S BASIC ELECTROMAGNETISM

II – 9 1 3 7

Alternating current circuits and fields, electromagnetic induction and wave propagation. This course normally follows PHY 283F and the laboratory includes experiments relevant to both.

G. J. Luste

PHY 303F THERMODYNAMICS

IV – 5p 2 – 8

The general principles of classical thermodynamics are discussed and related to statistical physics. Representative applications in fluids, solids, magnetic systems and phase transitions are considered. The kinetic theory of gases is treated.

G. M. Graham

PHY 304S SOLID STATE PHYSICS

III – 5g, 5p 2 3 9

Description of Crystal Structures. Diffraction of x-rays by crystals, classification of solids. Elastic constants of crystals. Lattice vibrations. Thermal properties of solids. Dielectric properties. Textbook: *Principles of Solid State Physics* – Levy.

F. D. Manchester

PHY 305F NUCLEAR AND PARTICLE PHYSICS

III – 5p 2 – 5

Important discoveries in nuclear and particle physics. Properties of the nucleus and of nuclei. The measurement of atomic masses; nuclear binding energies, binding energy and mass formulas, liquid drop model and fission. Introduction to nuclear shell and collective models. Interaction of charged particles and uncharged particles with matter; particle detection, energy and momentum measurements. Radioactive decay phenomena: theory and experiment. Nuclear reactions and cross sections. Particle accelerators. Reference Book: *Elements of Nuclear Physics* – Meyerhof.

D. A. L. Paul

PHY 307S APPLIED NUCLEAR PHYSICS

III – 5p 2 – 6

Fission and fusion. Tracer techniques. Biological effects of radiation. Applications of nuclear techniques in various fields. Neutron and scintillation radiography. Activation analysis. Textbook: *Nuclear Radiation Physics* – Lapp & Andrews.

B. M. Moores

PHY 308X EXPLORATION GEOPHYSICS

IV – 9 2 3 9

An introduction to the physical principles underlying the important methods of geophysical prospecting. Particular attention is given to seismic, gravitational, magnetic and electromagnetic methods. Textbook: *Introduction to Geophysical Prospecting* – Dobrin.

G. F. West

PHY 309F MOLECULAR BIOPHYSICS

III – 5p 2 – 5

The physical and chemical properties of some biologically important macromolecules in relation to their functions. Techniques such as sedimentation, chromatography, spectroscopy, scattering of photons and electrons. The course is designed to give students with a physics and chemistry background an insight into the application of the exact sciences to the solution of biological problems.

P. F. Ottensmeyer

PHY 310S CELLULAR BIOPHYSICS

III – 5p 2 – 6

The emphasis will be on the application of principles from physics, chemistry and genetics to quantative studies in cell biology. Selected areas in biophysics such as cellular differentiation, the regulation of macromolecular biosynthesis, and the application of biophysical methods to problems in medicine, will be discussed in detail.

R. A. Phillips

PHY 380F QUANTUM PHYSICS

III – 5nt, 5p 3 3 12

Schroedinger's theory of quantum mechanics, perturbation theory, one-electron atoms, magnetic moments, spin and relativistic effects, identical particles, multi-electron atoms, transition probabilities and the Golden Rule.. Examples will be taken from atomic physics, molecular physics and to a smaller extent nuclear and particle physics. A core course. Laboratory experiments in the areas of atomic, molecular, solid state, nuclear and particle physics are available. Textbook: *Fundamentals of Modern Physics* – Eisberg.

E. J. Allin

PHY 381S STATISTICAL PHYSICS

III – 5e 2 – 6

Kinetic theory of gases. Pressure and energy of a gas. Distribution of velocities. Transport phenomena. Review of basic concepts and formulas of thermodynamics. Statistical mechanics. Classical statistics of Maxwell-Boltzmann. Statistical thermodynamics. Monatomic gas. Equipartition theorem. Specific heat of diatomic gases. Quantum statistics: Bose-Einstein and Fermi-Dirac Statistics. Laws of radiation. Electron gas. Fluctuations. Laboratory experiments in the area of atomic, molecular, solid state, nuclear and particle physics are available. Textbook: *Thermodynamics, the kinetic theory of gases and statistical mechanics* – Sears.

E. J. Allin

PHY 381X STATISTICAL PHYSICS

III – 5g 2 1½ 9
III – 5g 2 3 12

Course 381S with laboratory assignments.

PHY 400 QUANTUM THEORY

IV – 5p 2 – 8, 2 – 8

Waves and particles, wave packets, uncertainty principle. Schroedinger equation, expectation values, operators, eigenvalues, eigenfunctions, one dimensional problems. Angular momentum, central force problems, Pauli spin theory, identical particles, Pauli principle, applications to atoms and molecules. Zeeman effect. Perturbation theory, secular equations, time dependent perturbation theory, transition probabilities. Charged particles moving in electromagnetic fields, scattering theory.

D. Rowe, R. E. Pugh

PHY 401C STATISTICAL MECHANICS (Part 1)

IV – 5p 2 – 8

Maxwell-Boltzmann, Bose-Enstein and Fermi-Dirac statistics with applications. Elementary theory of irreversible phenomena. Textbook: *Fundamentals of Statistical and Thermal Physics* – Reif.

P. A. Griffin

PHY 401D STATISTICAL MECHANICS (Part 2)

IV – 5p 2 – 8

Theory of imperfect gases, phase transitions. The Boltzmann equation, fluctuation theory and correlation functions. Textbook: *Fundamentals of Statistical and Thermal Physics* – Reif.

P. A. Griffin

PHY 403C NUCLEAR PHYSICS (Part 1)

IV – 5nt, 5p 2 – 8

General properties of nuclei and the nucleons. Nuclear masses, nuclear binding energy. Nuclear structure, meson theory and quark model. Nucleon-nucleon scattering phenomenology and the nucleon-nucleon force. The deuteron. Shell and collective models of nuclear structure. Textbooks: *Fundamentals of Modern Physics* – Eisberg; *Nuclear and Particle Physics* – Paul.

A. E. Litherland

PHY 403D NUCLEAR PHYSICS (Part 2)

IV – 5p 2 – 8

Nuclear reactions. Alpha decay. Fission. Electromagnetic interactions: gamma decay, photonuclear reactions, electron scattering and electrodisintegration. Weak interactions: beta decay, inverse beta decay. Parity non-conservation and related phenomena. Textbooks: *Fundamentals of Modern Physics* – Eisberg; *Nuclear and Particle Physics* – Paul.

J. Goldemberg

PHY 404S HIGH ENERGY PHYSICS

IV – 5p 2 – 8

Description of the elementary particles and their decay. Symmetries: charge independence (SU2), strangeness conservation, SU3 and quarks. Notions of scattering theory such as the S-Matrix, partial waves, unitarity, dispersion relations and Regge poles. Emphasis will be on the phenomenology. Textbook: *Elementary Particles* – Frazer.

R. K. Logan

PHY 405C SOLID STATE PHYSICS (Part 1)

IV – 5p 2 – 8

Scattering from rigid lattices. Van Hove structure factor. Bragg scattering; reciprocal lattice. Excitations in harmonic crystals. Localized modes. Density of states. Anharmonic interactions. Free electron theory. Tunneling. Transport theory. Screening and plasmons. Textbooks: *Introduction to Solid State Physics* – Kittel, *Principles of Theory of Solids* – Ziman.

F. D. Manchester

PHY 405D SOLID STATE PHYSICS (Part 2)

IV – 5p 2 – 8

Brillouin zones, band structure, Fermi surfaces. Semiconductors. Electrons in a magnetic field. Superconductivity. Dimagnetism, paramagnetism. Ferromagnetism; antiferromagnetism. Textbooks: *Introduction to Solid State Physics* – Kittel, *Principles of Theory of Solids* – Ziman.

E. Fawcett

PHY 406F INTERACTION OF RADIATION WITH MATTER

IV – 5p 2 – 8

A detailed survey with theoretical treatment and applications of: dispersion theory, shape and broadening of spectral lines, transition probabilities and intensities, scattering, diffraction and interference of electromagnetic waves, optical properties of metals and crystals, coherent radiation and nonlinear optics. Textbooks: *Principles of Optics* – Born and Wolf; *Optical Physics* – Garbuny; *Radiation and Optics* – Stoue.

B. P. Stoicheff

PHY 407S MAGNETIC RESONANCE

IV – 5p 2 – 8

Motion of free spins. Macroscopic aspects. Crystal fields and the effective spin Hamiltonian. Magnetic interactions in a rigid lattice. Thermal relaxation in liquids and gases. Thermal relaxation in solids. Electric quadrupole effects. Dynamic nuclear orientation. Textbooks: *Principles of Magnetic Resonance* – Slichter; *Paramagnetic Resonance* – Pake.

R. L. Armstrong

PHY 408F GROUP THEORY AND MOLECULAR PHYSICS

IV – 5p 2 – 8

Abstract group theory. Theory of groups and group representations. Crystallographic point groups. Group theoretical matrix element theorems. Selection rules. Directed valence. Born-Oppenheimer approximation. Rotation and vibration of diatomic and polyatomic molecules. Textbook: *Group Theory and Quantum Mechanics* – Tinkham.

H. L. Welsh

PHY 409S QUANTUM OPTICS

IV – 5p 2 – 8

Stimulated emission. Laser theory. Coherence. Nonlinear optics including harmonic generation, parametric processes, stimulated scattering and self-focussing. Textbooks: *Nonlinear Optics* – Bloembergen; *Lasers* – Lengyel; *Quantum Optics* – Yariv.

A. D. May

PHY 410 RELATIVITY THEORY

IV – 5p 2 – 8, 2 – 8

Special theory: principle of relativity, Lorentz transformations, Minkowski space, tensor algebra. Relativistic particle dynamics, collision theory. Relativistic field theory, hydrodynamics, Maxwell field, electrodynamics of material bodies, Klein-Gordon field. General theory: Principle of equivalence, general covariance, tensor analysis. Einstein equations, Schwarzschild solution, geodesics, gravitational collapse, black holes. Geometrodynamics, superspace, quantization of Einstein equations. Cosmology: cosmological models, Robertson-Walker metric, mix master universe.

J. Van Kranendonk

PHY 411 CLASSICAL PHYSICS OF CONTINUA

IV – 5g 2 – 6, 2 – 6

Analysis of deformation of continuous medium. Stress tensor. Constitutive equations. Viscosity. Viscoelasticity. Wave motion in continuous media. Viscous Hydrodynamics. Stability theory. Introduction to theories of turbulence. Textbook: *Introduction to the Mechanics of Continua* – Prager.

R. A. Wiggins

PHY 412 PHYSICS OF THE EARTH

III – 9, IV – 5g 2 – 6, 2 – 6

Seismology and the internal constitution of the Earth, gravity and the figure of the Earth, geomagnetism, temperature and thermal history, radioactivity and the age of rocks; physical basis of global tectonics. Reference Books: *Physics of the Earth* – Stacey; *Physics of the Earth* – Garland; *Core and Crust* – Mantle.

G. D. Garland

PHY 413X THEORY AND APPLICATION OF GEOPHYSICAL METHODS

IV – 5g 2 6 12, 2 6 14

A course on the mathematical theory of seismic, magnetic electrical and gravitational methods in pure and applied geophysics. The associated laboratory course stresses the experimental and mathematical techniques applicable to the geophysical sciences. Textbook: *Interpretation Theory in Applied Geophysics* – Grant & West.

PHY 414 ATMOSPHERIC PHYSICS

IV – 5g 2 – 6, 2 – 6

Meteorological measurements, radiation, atmospheric statics and conditions for equilibrium, atmospheric thermodynamics, equations of motion, synoptic charts, the general circulations, condensations, condensation physics, atmospheric electricity. Wind structure near the ground, evaporation, the stratosphere.

A. W. Brewer

PHY 427F QUANTUM PHYSICS LABORATORY I

IV – 5p – 5 8

Experiments of both a pure and applied nature are available in the areas of atomic, molecular, solid state, nuclear and particle physics. The experiments are open-ended; the student may spend more or less time on a particular experiment depending on his interest. The laboratory is open five days a week.

A. D. May, A. E. Litherland

PHY 428S QUANTUM PHYSICS LABORATORY II

IV – 5p – 5 8

This course is an extension of PHY 427F. The experiments are similar but at a more advanced level. In addition several experiments of a research nature may be undertaken outside the laboratory. The laboratory is open five days a week.

A. D. May, A. E. Litherland

STATISTICS

(Department of Mathematics)

STA 282S PROBABILITY AND STATISTICS

II – 3, 8, 9 2 2 8

Elements of probability theory. Binomial, Poisson and normal distributions. Sampling theory. Significance tests. Control charts. Least squares.

A. Saleh

STA 287S PROBABILITY AND STATISTICS

II – 5 3 1 9

Definition of probability; binomial, Poisson, and normal distribution; frequency; sampling distributions. Examples of estimation, hypothesis testing, control charts, regression, and analysis of variance.

M. Srivastava

STA 291F PROBABILITY

II – 4 229

Elements of probability theory. Random variables. Discrete and continuous distributions. Moments. Independence. Conditional probabilities. Theory of sampling.

J. C. Fu

STA 292S STATISTICS

II – 4 229

A continuation of STA 291F. Tests of significance and confidence limits. Control charts. Introduction to the analysis of variance, design of experiments and regression.

J. C. Fu

STA 392S PROBABILITY AND STATISTICS

III – 4 229

A continuation of STA 292S. General regression theory. Elements of the theory of sample surveys.

P. Andrews

LIST OF IN-HOUSE NON-TECHNICAL ELECTIVES FOR 1971–72

The following in-house non-technical electives will be available to students in all four years in the session 1971–72. Two half courses or one full course may be taken as a non-technical elective by students in their first and second years, and as an open elective by students in their third and fourth years. All courses consist of two hours of lectures per week.

These courses will only be offered in a given term if there is sufficient enrolment, and the enrolment may have to be limited in some courses.

ECO 281 ECONOMICS

An introduction to the study of Economics with special reference to the problems of the Canadian economy. Those students who obtain a satisfactory term mark will not be required to write the final examination. This course has equivalent value to ECO 100 as a prerequisite for advanced courses in Economics. It may not be combined with ECO 100 or ECO 102 in any degree program.

ENG 281F/S EFFECTIVE WRITING

An "effective" writer knows how to express his ideas clearly and precisely, how to employ the laws of logic in ordering and supporting an argument, and how to use language persuasively. This course will involve discussion of the theory and method of various kinds of writing, supplemented by close consideration of examples of effective prose and by frequent and varied practical exercises designed to develop writing skills.

ENG 282F/S TWENTIETH-CENTURY LITERATURE
This course provides an introduction to twentieth-century literature through a study of representative works of important playwrights, poets, novelists and short-story writers.

ENG 283F/S CANADIAN LITERATURE
This course will deal with representative works of Canadian poets, novelists, short-story writers and essayists, and will consider some of the historical and cultural forces that helped to shape the Canadian imagination.

ENG 284F/S VARIETIES OF FICTION
This course is designed to increase enjoyment and understanding of the various forms of prose fiction (the novel, the novella, the short-story) through close consideration of representative works, including some recently written material.

ENG 285F/S DRAMA AND THE MODERN THEATRE
This course is designed to increase understanding and enjoyment of drama. It will deal with plays (of whatever period) which are still being performed in the contemporary theatre and will consider the reasons for their theatrical effectiveness for modern audiences. Where possible, attention will be given to filmed drama and to plays currently being performed in Toronto.

ENG 286F/S LITERATURE AND SCIENCE
This course will explore some of the ways in which the methods and discoveries of science have made and are making an impact upon literature and will deal with a selection of the wide variety of works (from metaphysical poetry to science fiction) which were written in response to the scientific and technological ideas of their time.

HPS 280F/S HISTORY OF SCIENCE AND TECHNOLOGY
An introduction and survey to the history of science and technology to show the growth and interaction of the two fields from the earliest times to the XXth century. Ideas originating within the two disciplines will be discussed along with their interactions and external influences.

HPS 281F HISTORY OF TECHNOLOGY AND ENGINEERING UP TO THE INDUSTRIAL REVOLUTION
A treatment of the origins of technology and engineering covering development in the civilizations of the Ancient World, that of Greece and Rome, the Medieval World and the period of the Renaissance. Emphasis will be placed on the developments of techniques and of machines with an indication of the context in which these occur.

HPS 282S HISTORY OF TECHNOLOGY AND ENGINEERING FROM THE INDUSTRIAL REVOLUTION TO THE PRESENT

A treatment of the development of machines and the utilization of new power sources during the period under discussion. The interrelation of new techniques and chemical processes with economic and other factors as well as the interaction between science and technology will be included. These courses may be offered in more than one section if demand calls for it.

HPS 283S TECHNOLOGY, ENGINEERING AND SOCIETY

An historical treatment of the interaction of technology, engineering and society. Material will be selected from throughout history, but concentration will be placed on the period since the Industrial Revolution where the nature of society is seen to be highly affected by technological developments and engineering accomplishments. The nature of the technical knowledge which permitted these changes will be discussed along with the adoption of the specific processes, machines and devices. Consideration will be given to the effects of man as a technological innovator on the environment and eco-system, including biological effects. (It is not considered at this time that attendance in this course should be limited, but if presumed attendance is too large for classroom discussion, it will be restructured to meet periodically in small groups.)

PHL 291F SCIENCE AND SOCIETY

A philosophical examination of the role of the scientist, technologist, and engineer in contemporary society, including some of the following problems: pollution, and its control, war research, the "think tank", technocracy, nationalism.

PHL 292S SCIENCE AND PHILOSOPHY

The advance of the physical, social, and life sciences has produced successive changes in concepts familiar to the ordinary man (space and time; cause and effect; man and animal; purpose, motive, freedom). The philosopher has attempted to work out the implications of these changes. This course will examine some of these attempts.

VII

General Regulations; Examinations

The curriculum for 1971–72 reflects the introduction of a term system in which all courses of instruction (with the exception of certain courses taken in the Faculty of Arts and Science) will be one term in duration. There are two terms in the annual session, each concluding with final examinations in the courses offered. With the exception of the First Year, for which there are special provisions, students will be evaluated for promotion at the end of each term.

It is possible, within limits, for a student to proceed at a pace slower or faster than the normal rate. A regular program consists of a maximum of six courses per term* with a total weight of 48 units; with the approval of the Chairman of his Department a student enrolled in the second or higher years may elect to reduce his load to a minimum of 40 units per term, or to increase it to a maximum of 60 units. First-year students may not take less than the normal load of 48 units.

The regulations concerning standing and promotion are set out in detail below.

I. DEFINITIONS

Fall Term Average – is calculated on the basis of all courses in which the student is enrolled at the start of the eighth week of the term, with the weighting factor for each course being the units assigned to it. The results of summer or pre-session courses taken for credit will be included in the calculation of the Fall Term Average with their full unit value. The results of full-year courses taken in another Faculty will not be included in the calculation of the Fall Term Average, except in the case of certain courses for which arrangements have been made for the submission of marks on a term basis.

Spring Term Average – is calculated on the basis of all courses in which the student is enrolled at the start of the eighth week of the term with the weighting factor for each course being the units assigned to it. Full courses taken from other Faculties will be included in computing the average on the basis of their units for the spring term only. When the Fourth Year Thesis is spread over two terms and a department elects to report marks only at the end of the second term, the mark will have a weight equal to the sum of the Thesis weights for the two terms.

Year Average – is the weighted average of all courses taken in the fall and spring terms.

*In the session 1971–72 seven courses per term are specified in some programs.

Core Course – any course in a program that is so designated by a Department.

Evaluation Period – the fall and spring terms taken together is the principal evaluation period for students who are taking First Year for the first time. For all other students, the evaluation period is a single term.

II. REGULATIONS

1. To qualify for a degree, a student must complete a full undergraduate program.

2. (*a*) The normal load is 48 units per term but a student may reduce his load to approximately 40 units or increase it to 60 units if his Department Chairman approves, thereby increasing or decreasing the time required to complete the degree.

(*b*) A student in the First Year for the first time or in the first term of First Year for a second time will not be permitted to reduce his load.

(*c*) In the final term a student may carry less than the normal minimum load of 40 units if the aggregate weight of the courses required for completion of his program is less than 40 units.

3. A student taking the First Year program in Division A who:

(*a*) Obtains a Fall Term average of 50% or greater proceeds to the next term.

(*b*) Obtains a Fall term average less than 50% will be required to withdraw until the next Fall Term, at which time he will be re-admitted without petition. Upon re-admission he must repeat* all courses for which his mark was less than 60, and is placed on probation.

(*c*) Obtains a Year Average of 60% or greater proceeds to the next term.

(*d*) Obtains a Year Average less than 60% but greater than or equal to 55% proceeds to the next term and is placed on probation.

(*e*) Obtains a Year Average less than 55% but greater than or equal to 50% must repeat* all courses from both terms for which his mark was less than 60% and is placed on probation.

(*f*) Obtains a Year Average less than 50% will be required to withdraw.

4. A student taking the First Year program in Division B who:

(*a*) Obtains a Fall Term Average of 55% or greater proceeds to the next term in Division B.

(*b*) Obtains a Fall Term Average less than 55% but greater than or equal to 50% proceeds to the next term of a program in Division A.

(*c*) Obtains a Fall Term Average less than 50% will be required to withdraw until the next Fall Term at which time he will be re-admitted to Division A without petitioning. Upon re-admission, he must repeat* any course for which his mark was less than 60% and which has an equivalent in Division A and he is placed on probation.

(*d*) Obtains a Year Average of 66% or greater proceeds to the next term.

(*e*) Obtains a Year Average less than 66% but greater than or equal to 55% proceeds to the next term of a program in Division A.

(*f*) Obtains a Year Average less than 55% but greater than or equal to 50%

proceeds to the next term of a program in Division A and is placed on probation.

(*g*) Obtains a Year Average less than 50% will be required to withdraw until the next Spring Term at which time he will be re-admitted to Division A without petitioning. Upon re-admission he must repeat* any spring-term course for which his mark was less than 60% and which has an equivalent in Division A and he is placed on probation.

5. Any student not covered under Section 3 or 4 who:

(*a*) Obtains a Term Average of 60% or greater proceeds to the next term and, if applicable, is removed from probation.

(*b*) Obtains a Term Average less than 60% but greater than or equal to 55% proceeds to the next term if not already on probation, and is placed on probation.

(*c*) Obtains a Term Average less than 55% but greater than or equal to 50% and is not already on probation is placed on probation and must repeat* all courses taken in that term for which his marks were less than 60. Normally any student in this category who must repeat more than two of his technical courses will be required to withdraw for one term.

(*d*) Obtains a Term Average less than 50% will be required to withdraw.

(*e*) To be eligible for graduation a student must attain an average not lower than 60% in his final term; a student who fails to do so must repeat or replace courses to bring his average up to at least 60%. If a student's last term will involve less than the minimum academic load of 40 units he must repeat or replace courses to bring his average up to 60% in the second-to-last term.

6. A student will also be required to withdraw from the Faculty if:

(*a*) He is on probation and fails to obtain at least a 60% average so as to remove himself from probation.

(*b*) He has been placed on probation twice before and obtains an average which would place him on probation again.

7. (*a*) A student who is required to withdraw:

(i) Must wait until one full term has elapsed before applying for re-admission.

(ii) Will be considered for re-admission on his merits in competition with all other applicants.

(*b*) If re-admitted after being required to withdraw, a student must repeat* all courses taken in his last evaluation period for which his mark was less than 60% and is placed on probation.

8. A student required to repeat* courses can make up the minimum academic load by:

(*a*) Taking courses from the next higher year of the program if he has obtained a mark of 50% or greater in the appropriate prerequisites taken in his previous evaluation period.

(*b*) Taking courses of comparable level to his failed courses. Normally these will not relieve the student of completing all the required courses in the program in which he is enrolled.

(*c*) Repeating courses which he has previously completed.

SUMMARY OF REGULATIONS FOR PROMOTION AND FAILURE

A_T = Term Average A_Y = Year Average

Evaluation Period	Average	Decision
Term 1 (First Year)	*Division A*	
	$A_T \geqslant 50\%$	Proceed to next term (Reg. 3a)
	$A_T < 50\%$	Required to withdraw for one term (Reg. 3b)
	Division B	
	$A_T \geqslant 55\%$	Proceed to next term (Reg. 4a)
	$50\% \leqslant A_T < 55\%$	Required to transfer to Division A (Reg. 4b)
	$A_T < 50\%$	Required to withdraw for one term (Reg. 4c)
Term 1 and 2 (First Year)	*Division A*	
	$A_Y \geqslant 60\%$	Proceed to next term (Reg. 3c)
	$55\% \leqslant A_Y < 60\%$	Proceed to next term on probation** (Reg. 3d)
	$50\% \leqslant A_Y < 55\%$	Repeat* all courses with mark less than 60% and go on probation** (Reg. 3e)
	$A_Y < 50\%$	Required to withdraw (Reg. 3f)
	Division B	
	$A_Y \geqslant 66\%$	Proceed to next term (Reg. 4d)
	$55\% \leqslant A_Y < 66\%$	Proceed to next term in Division A (Reg. 4e)
	$50\% \leqslant A_Y < 55\%$	Proceed to next term in Division A on probation** (Reg. 4f)
	$A_Y < 50\%$	Required to withdraw for one term (Reg. 4g)
All Other Terms	$A_T \geqslant 60\%$	Proceed to next term (Reg. 5a)
	$55\% \leqslant A_T < 60\%$	Proceed to next term on probation** (Reg. 5b)
	$50\% \leqslant A_T < 55\%$	Repeat* all courses with mark less than 60% and go on probation** (Reg. 5c)
	$A_T < 50\%$	Required to withdraw (Reg. 5d)

*Courses which are not designated as core courses need not be repeated but can be replaced by a course of comparable level.

**A student will be required to withdraw if:

(*A*) He is on probation and fails to obtain at least a 60% average so as to remove himself from probation. (Reg. 6a)

(*B*) He has been on probation twice before and obtains an average that would place him on probation again. (Reg. 6b)

GRADING SYSTEM

1. The student's work in individual courses is graded in the following manner:

Marks	*Grade*
80 – 100%	1
70 – 79%	2
60 – 69%	3
50 – 59%	4
Below 50%	5

2. Honour standing in the work of a term or a year is granted to students who achieve a weighted average of 75% or greater.

3. Honour graduate standing will be granted to students who obtain honours in the final year and in any one previous year.

ATTENDANCE

1. Students proceeding to the degree are required to attend the courses of instruction and the examinations in all subjects prescribed. A student whose attendance at lectures or laboratories, or whose work, is deemed by the Council of the Faculty to be unsatisfactory may have his registration cancelled at any time.

2. Students must conform to all lecture room and laboratory regulations. Reports, briefs, theses and drawings become the property of the Council to dispose of as it may see fit. Drawings, briefs and field notes will not be accepted unless they have been made at the time and place provided in the time table.

APPEALS

1. A student should submit to Council immediately after its occurrence, evidence of any illness or mishap which occurs during the term, any petition for leniency on account of such incidents may be refused consideration if received after the third day following the last day of examinations.

2. A student wishing to appeal to the Senate against a decision of the Council of the Faculty should consult the Secretary of the Faculty or the office of the University Registrar about the preparation and submission of his petition to the Secretary of the Senate.

VIII

Medals, Prizes, Scholarships and Bursaries

Through the generosity of friends of the University, governments and commercial organizations, encouragement has been given to undergraduate work in the various branches of engineering study by the establishment of the scholarships, prizes, bursaries and medals listed in the following pages.

ADMISSION SCHOLARSHIPS AND BURSARIES

Ontario Students:
Scholarships and bursaries available to students entering the First Year are listed on page 158. For full details concerning these awards, applicants should consult the Calendar of Admission Awards, which is available at Secondary Schools or from the Office of Student Awards, Simcoe Hall, University of Toronto. Applications, which must be made through the Principal of the Secondary School, close on May 1 annually.

Non-Ontario Students:
All non-Ontario students should apply to the Office of Student Awards, Simcoe Hall, University of Toronto. A limited number of scholarships is reserved for students living outside the Province of Ontario, but as competition is keen such students must not count on receiving assistance but are advised rather to ensure that they have sufficient funds from their own government or from private sources to cover all probable expenses.

IN-COURSE SCHOLARSHIPS AND BURSARIES

Scholarships, prizes, bursaries and loans available to students in attendance in the Faculty are listed on pages 158 to 161. Where it is necessary to make application for an award it is so stated in the description and particulars are given as to how the application should be made. In all other cases the award is made on the recommendation of the Faculty Council and no application is necessary.

GENERAL TERMS AND CONDITIONS

Scholarships, prizes and medals granted in recognition of academic proficiency are awarded at the end of the spring term, the candidates being ranked on the basis of their achievement in the spring term and the fall term previously completed.

To be eligible for any scholarship or award granted solely on academic standing a student must have completed not less than the normal full load within the two terms upon which the award is based. A student whose program in these two terms contains repeated courses will only be eligible if his aggregate of new courses is equal to or greater than 96 units.

Unless otherwise specified in the terms of award, scholarships, medals and prizes based solely upon academic standing will be awarded only to students who have achieved honours in the work upon which the award is granted. If the award is based on a single course or on a part of the work of the term, the candidate must obtain unconditioned pass standing in the work of the term, but need not obtain honours on the work of the term unless the terms of the award so specify.

A candidate will not be permitted to hold more than one award in a session unless the statute of each of the awards concerned or the calendar specifies otherwise. Only one of those awards marked with an asterisk may be held in any one year.

Medals, after they have been suitably engraved, will be given without delay to the winners or forwarded to them by registered mail.

Awards granted to members of graduating classes other than awards for graduate study and research, will be paid in one instalment as soon as possible after the granting of the awards.

All other awards will be paid (i) if of the value of $100 or less, in one instalment on November 20 and (ii) if of the value of more than $100 in two equal instalments, the first on November 20 and the second on January 20, in the session following the granting of the awards. Payment will be made only if the candidate is in regular attendance in the Faculty and, if the Calendar so specifies, in the course in which the award is established or granted.

The Senate may, on the recommendation of the Faculty, permit a candidate to whom an award has been granted to postpone attendance upon lectures and laboratory classes for one year. Further postponement may be permitted on application.

NOTE – As the value of an endowed scholarship or prize is dependent on the actual income of the fund, it is possible that the value of certain scholarships and prizes at the time of payment may be greater or less than the amount stated in the calendar.

In those cases where the amount of the award is not payable from income earned on an endowed fund, payment will be dependent on the receipt of the amount of the annual award from the donor.

AVAILABLE TO STUDENTS ENTERING THE FIRST YEAR

(† *indicates that application is required*)

Alumni Association War Memorial Scholarships	†	$ 500	page 185
Alcan Scholarship	†	$ 500	162
J. P. Bickell Foundation Scholarships	†	$ 500	165
J. W. Billes Admission Scholarships	†		166
Children of War Dead Education Assistance	†		167
Engineering Alumni Admission Scholarships (7)	†	$1000	170
Grabill Admission Scholarship	†	$ 500	171
Hagarty Memorial Scholarship	†	$ 60	171
The Murray Calder Hendry Scholarship	†	$ 500	172
Roy Jarvis Henry Admission Scholarships (3)	†	$ 500	173
The Leonard Foundation Scholarships	†		174
J. Edgar McAllister Foundation	†		174
John Wolfe McColl Awards	†		174
Lachlan Dales McKellar Admission Scholarships (2)	†	$ 500	176
George R. Mickle Admission Bursaries	†	$1000	178
O.H.A. War Memorial Scholarship	†	$ 200	178
Ontario Chapter American Society for Metals Bursaries	†	$ 150	163
Ontario Student Awards Program	†		168
A.P.E.O. Admission Scholarship	†	$ 500	179
Regular Officer Training Plan	†		181
Helen E. Rogers Admission Scholarships	†		182
Simpsons-Sears Limited (Northern Ontario) Scholarship	†	$ 100	183
Walter Sterling Admission Scholarships	†		184
U.T.S. Engineering Scholarship	†	$ 250	186
Wallberg Admission Scholarships (2)	†	$ 500	186

AVAILABLE TO STUDENTS COMPLETING THE FIRST YEAR

(† *indicates that application is required*)

Baptie Scholarship		$ 175	164
Canadian Bechtel Limited Bursaries	†		165
J. P. Bickell Foundation Scholarships			165
T. H. Bickle Prize		$ 30	166
Crocker Foundation Bursaries	†		168
John M. Empey Scholarship		$ 170	169
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		173
Johnson's Wax Scholarship		$ 800	173
John Wolfe McColl Awards	†		174
Garnet W. McKee-Lachlan Gilchrist Scholarship in Engineering Science		$ 110	175
MacLennan – MacLeod Memorial Prize		$ 25	176

*Marsland Engineering Ltd. Scholarship		$ 250	177
Ontario Chapter American Society for Metals Bursaries	†		163
Ontario Student Awards Program	†		168
Paulin Memorial Scholarship		$ 550	179
Procter and Gamble Bursary	†		179
*Professional Engineers Scholarship		$ 250	179
Ransom Scholarship in Chemical Engineering		$ 250	180
Frederick W. Schumacher Scholarship	†		182
S. Ubukata Fund	†		185
*Wallberg Undergraduate Scholarships (2)		$ 500	186

AVAILABLE TO STUDENTS COMPLETING THE SECOND YEAR

(† *indicates that application is required*)

Harvey Aggett Memorial Scholarship		$ 75	162
Ardagh Scholarship		$ 550	164
A.S.H.R.A.E. Bursaries	†		163
Automotive Transport Association Bursary	†		164
Babb Bursary Fund	†		164
Canadian Bechtel Limited Bursaries	†		165
J. P. Bickell Foundation Bursaries	†		165
J. P. Bickell Foundation Scholarships			165
T. H. Bickle Prize		$ 30	166
Carveth Metallurgical Ltd. Bursary	†	$ 500	167
5T6 Civils Scholarship	†	$ 200	167
Crocker Foundation Bursaries	†		168
Cyanamid of Canada Scholarship		$ 900	168
John M. Empey Scholarship		$ 170	169
J. A. Findlay Scholarship		$ 100	170
Hugh Gall Award		$ 275	171
Hydro-Electric Power Commission of Ontario Bursary	†	$ 500	173
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		173
Charles Gordon Manning Prize			177
*Marsland Engineering Ltd. Scholarship		$ 250	177
James L. Morris Memorial Prize		$ 125	178
Ontario Chapter American Society for Metals Bursaries and Scholarship	†		163
Ontario Student Awards Program	†		168
*Professional Engineers Scholarship		$ 250	179
*Rhodes Scholarship	†	£1000	180
Frederick W. Schumacher Scholarship	†		182
Edith Tyrrell Memorial Bursary	†	$ 600	185
Wallberg Undergraduate Scholarships		$ 500	186
William R. Worthington Memorial Scholarship		$ 400	187

AVAILABLE TO STUDENTS COMPLETING THE THIRD YEAR
(† *indicates that application is required*)

American Institute of Industrial Engineers Scholarship		$ 150	163
A.S.H.R.A.E. Bursaries	†		163
Babb Bursary Fund	†		164
F. W. Baldwin Prize		$ 75	164
Canadian Bechtel Limited Bursaries	†		165
J. P. Bickell Foundation Bursaries	†		165
T. H. Bickle Prize		$ 30	166
*Boiler Inspection and Insurance Company Scholarship		$ 300	166
*Chevron Standard Limited Scholarship		$ 500	166
Chemical Institute of Canada Prize		$ 25	167
Cominco Scholarships	†	$ 800	168
Crocker Foundation Bursaries	†		168
Dow Chemical of Canada Limited Award		$ 500	169
John M. Empey Scholarship		$ 170	169
E.I.C. Prize		$ 100	170
Engineering Society Semi-Centennial Award		$ 75	170
J. A. Findlay Scholarship		$ 100	170
James Franceschini Foundation Scholarship		$ 300	171
Chester B. Hamilton Scholarship		$ 500	172
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		173
*Jenkins Scholarship in Engineering		$ 200	173
Loan Funds	†		187
J. A. D. McCurdy Prize		$ 75	175
Alexander MacLean Scholarship		$ 250	176
*Marsland Engineering Ltd. Scholarship		$ 250	177
Ontario Chapter American Society for Metals Bursaries and Scholarship	†		163
Ontario Student Awards Program	†		168
*Professional Engineers Scholarship		$ 250	179
RCE Memorial Scholarship	†	$ 125	181
Rosedale Chapter, I.O.D.E. Award	†	$ 400	182
Don Salt Memorial Scholarships	†	$ 500	182
Murray F. Southcote Scholarship		$ 100	184
Frederick W. Schumacher Scholarship	†		182
Edith Tyrrell Memorial Bursary	†	$ 600	185
Wallberg Undergraduate Scholarships		$ 500	186
C. H. E. Stewart Bursaries	†		184

AVAILABLE TO STUDENTS COMPLETING THE FOURTH YEAR
(† *indicates that application is required*)

Henry G. Acres Medal			162
American Society of Lubrication Engineers Prize		$ 75	163
J. P. Bickell Foundation Bursaries	†		165
Babb Bursary Fund	†		164
Crocker Foundation Bursaries	†		168
Electrical Manufacturing Co. Limited – Montel Inc. Prize		$ 50	169
Hamilton Watch Award			172
Loan Funds	†		187
Massey-Ferguson Ltd. Scholarships (2)	†	$ 500	177
Ontario Student Awards Program	†		168
Otto Holden Scholarship		$ 750	178
Professional Engineers Gold Medal			180
J. E. Reid Memorial Prize		$ 50	180
Wallace Award, Society of Automotive Engineers Prize		$ 100	184
Society of Chemical Industry Merit Award			184
"Second Mile Engineer" Award	†	$ 200	183
W. S. Wilson Medals			186

HENRY G. ACRES MEDAL

The Henry G. Acres Medal is the gift of Mrs. Henry G. Acres in memory of her late husband, Henry G. Acres, M.E., D.Sc., a graduate of the School of Practical Science in the class of 1903. Throughout his professional life Dr. Acres was associated with major power developments in Canada and abroad. As chief hydraulic engineer for the Hydro-Electric Power Commission of Ontario in the period 1911 to 1923, he was responsible for the design and construction of nearly twenty power plants, including the Queenston-Chippewa development. Entering private practice in 1924, and until his death in 1945, he continued to widen and extend his interests. He became chief engineer of the Grand River Conservation Commission and responsible for the design and construction of the Shand dam and related work. Later, he was consulting engineer for the extensive power developments at Shipshaw on the Saguenay River, which was vital to the production of aluminum for war purposes. Many of the provinces of Canada sought his services and he advised with respect to work in Newfoundland, South America and India.

This medal is awarded annually to the student in the Fourth Year who is registered in the course in Civil, Mechanical, or Electrical Engineering, and who obtains the highest aggregate percentage at the annual examinations of the Third and Fourth Years, provided always that the student obtains honour standing in the examinations of the Fourth Year. Receipt of the medal does not preclude a student from being granted such other award as may in the opinion of the Council be appropriate.

HARVEY AGGETT MEMORIAL SCHOLARSHIP

This scholarship was donated by the late Mr. J. T. Aggett, of Toronto, as a perpetual memorial to his son, the late Lieutenant Harvey Aggett, who enlisted in March, 1915, during his second year in this Faculty, and was killed in action at Passchendaele on November 6, 1917.

This annual scholarship of the value of the annual income from the fund is to be awarded to a student of the Second Year in this Faculty who, obtaining honours and being one of the first three in his year by his standing at the annual examnations, has been adjudged highest of the three in general student activities and service in the University during his period of attendance. When regulations do not permit the winner to hold this scholarship the students to be considered for the award shall be the first three in the year exclusive of any student who holds a scholarship of higher value.

ALCAN SCHOLARSHIP

The Aluminum Company of Canada, Limited, has made available an admission scholarship of a value of $500 to a student entering the First Year of an Honours Course in the Faculty of Arts and Science, the Faculty of Applied Science and Engineering or in the Faculty of Law. The recipient must attain an academic standing satisfactory to the Committee of Award and demonstrate financial need. It is tenable in the later years provided First Class standing is maintained. As the award is tenable for a possible four years and only one shall be outstanding in any year, the next Alcan Scholarship will become available in the session 1973–74.

Application should be made to the Office of Student Awards by May 1 on the regular Admission Scholarship Application form.

AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS SCHOLARSHIP

The Toronto Chapter, American Institute of Industrial Engineers offers a scholarship of $150 to a student entering the Fourth Year of the Industrial Engineering course who has consistently maintained a high academic standing, but not necessarily honour standing, during the previous three years.

A.S.H.R.A.E. BURSARIES

The Ontario Chapter of the American Society of Heating, Refrigerating and Air-Conditioning Engineers provides a number of bursaries, to a total value of $1500 annually, for students in the Second and Third Years of Electrical Engineering and Mechanical Engineering. Candidates must reside in Metropolitan Toronto or in an adjacent municipality; the awards will vary in value, according to individual need and the fund available. Application should be made to the Secretary of the Faculty by October 15, on the regular in-course bursary application form.

AMERICAN SOCIETY OF LUBRICATION ENGINEERS PRIZE

The Toronto section of the American Society of Lubrication Engineers offers an annual prize of $75 to a student in the Fourth Year in Mechanical Engineering whose Thesis dealing with Lubrication is considered by the Head of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory. The Prize is accompanied by a donation of $25 to the Department to purchase books on Lubrication.

ONTARIO CHAPTER, AMERICAN SOCIETY FOR METALS BURSARIES AND SCHOLARSHIP

The Ontario Chapter, American Society for Metals, provides several bursaries of a value of $150 each for students in all years of Metallurgy and Materials Science and in the Third and Fourth Years of the Materials Science option of Engineering Science. Bursaries are awarded on the basis of academic ability and the need for financial assistance. Applications should be made to the Secretary not later than October 1st. The first award was made for the Session 1958–59.

The Ontario Chapter also provides one scholarship of a value of $250 for academic excellence to be awarded to a student in Metallurgy and Materials Science after completion of the Second or Third Year or the Materials Science option of Engineering Science (Third Year). The first award was based upon the results of examinations in the Session 1970–71.

ARDAGH SCHOLARSHIP

The Ardagh Scholarship, of the annual value of the income from $7,500, has been provided in memory of his parents by Professor E. G. R. Ardagh, B.A.Sc., F.R.S.C., formerly professor of Applied Chemistry in the Faculty. It is awarded to the student who attains the highest standing in all Honours at the annual examination of the Second Year in the Course in Chemical Engineering. The first award was made on the results of the annual examination of 1946.

ATA TRUCKING INDUSTRY EDUCATIONAL FOUNDATION BURSARIES

The Automotive Transport Association of Ontario has established a bursary fund for students in the second or higher years of any undergraduate degree course who find themselves in serious financial need due to sudden, unexpected personal or family difficulties. Applications may be submitted to the University Registrar at any time during the session and the number and value of the bursaries will vary at the discretion of the Committee of Award.

THE BABB BURSARY FUND

Bursaries from this fund are available to students in any year of the Aeronautics Option in Engineering Science. Application is made through the Secretary of the Faculty.

THE F. W. BALDWIN PRIZE

The F. W. Baldwin Prize of a value of $75 was established by the trustees of a fund created by the members of the Number 3 Squadron, University Air Training Corps (1941–44), in memory of Frederick Walker "Casey" Baldwin, a graduate of the School of Practical Science, who made a significant contribution in the field of Aeronautics in Canada; and who flew, on March 12, 1908, near Hammondsport, N.Y., the "Redwing," the first biplane built by the Aerial Experiment Association.

It is awarded annually to the student registered in Third Year, Aeronautics Option, in Engineering Science, who, taking honours, ranks highest in the annual examinations of Third Year in "structural subjects."

The first award was made on the results of the examinations of the Session 1953–54.

BAPTIE SCHOLARSHIP

The Baptie Scholarship is derived from a bequest under the will of the late Mrs. Margaret W. Baptie, of Ottawa, and the Board of Governors has directed that a scholarship of one half the annual income shall be awarded annually to an engineering student on the record of the first Year. The Board of Governors also authorizes a remission of fees in the case of the holder of the scholarship, up to $75.

The conditions of the award are as follows: That the scholarship be awarded to the student who, in the annual examinations of the First Year, enrolled in any one of the courses of Civil Engineering, Mechanical Engineering, Chemical Engineering, Electrical Engineering, or Metallurgy and Materials Science, obtains the highest aggregate percentage of marks in those subjects which are common to the First Year curricula of those courses. The first award was made on the results of the annual examinations of the Session 1925–26.

CANADIAN BECHTEL LIMITED BURSARIES

Canadian Bechtel Limited has established Bursaries in the Faculty of Applied Science and Engineering of an annual value of $1,200 to provide not more than four awards, each of a minimum value of $200 and a maximum value of $600. Two awards will be made to First Year students and one or two awards to students registered in any year of the Faculty. Applicants must demonstrate financial need and have academic standing satisfactory to the Faculty Council.

Application must be made to the Secretary of the Faculty on or before Ocotber 1.

J. P. BICKELL FOUNDATION SCHOLARSHIPS

The Trustees of the J. P. Bickell Foundation have established scholarships, the number to be determined annually, in the Faculty of Applied Science and Engineering of a possible value of $1,500 payable $500 in the First Year and provided honours are obtained at the Annual Examinations, $500 in the Second and Third Years.

An applicant must obtain an average of at least 75% at the Ontario Grade XIII examinations immediately preceding his admission to the university and must undertake to enrol in Chemical Engineering, Metallurgy and Materials Science or Geological Engineering. Failing suitable candidates in the courses mentioned students registered in the Second Year Honour course in Geological Sciences, or Physics and Geology in the Faculty of Arts and Science who are academically qualified are eligible. These awards are of the same value and are tenable in the Second, Third and Fourth Years of the course, subject to maintenance of the required academic standing. If any scholarships are not awarded to those mentioned above, students registered in the Third Year of the Engineering Science course in the Faculty of Applied Science and Engineering and taking the Physical Metallurgy or the Geophysics option who are academically qualified are eligible. In this case the scholarship will have a value of $1,000, payable $500 in each of the Third and Fourth years, provided the required academic standing is maintained.

Applications from those entering First Year must be submitted to the Office of Student Awards not later than May 1 on the regular admission scholarship application form. In other cases, applications are not required.

J. P. BICKELL FOUNDATION BURSARIES

The Trustees of the J. P. Bickell Foundation have established the J. P. Bickell Foundation Bursaries in the Faculty of Arts and the Faculty of Applied Science and Engineering. An applicant must be enrolled in Honour Science or in Mathematics, Physics and Chemistry in the Faculty of Arts, in which case he must undertake to study mining or geology in his higher years; or be enrolled in a higher year of an honour course in the geological or geophysical field in the Faculty of Arts; or be enrolled in Chemical Engineering, Mining Engineering, Metallurgy and Materials Science, or Geological Engineering in any year of the Faculty of Applied Science and Engineering. He must demonstrate financial need and have satisfactory academic standing.

Application must be made to the Office of Student Awards on or before October 15.

THE T. H. BICKLE PRIZE

The T. H. Bickle Prize is the gift of Mr. and Mrs. E. W. Bickle in memory of their son, T. H. Bickle, an undergraduate of Trinity College and a member of the Senior Intercollegiate Swimming Team at the time of his death in 1937. The income from the endowment fund will be used to purchase a suitable prize to be awarded annually to a member of the Senior Intercollegiate Swimming Team of this University in any year, faculty or school. The Committee of Award shall consist of the Dean of the Faculty of Arts, the University Registrar, the Director of Athletics, and the Honorary Coach of Swimming. In awarding the Prize the Committee shall consider the character, scholarship, and general interests of the members of the team.

J. W. BILLES ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of J. W. Billes, open to students entering any degree course in the University. The value in each year is a minimum of $250 and a maximum of $1,500 dependent upon the financial need of the recipient. Applicants must satisfy the normal admission scholarship standards in their Grade XIII examinations to be eligible for an award and maintain first class honour standing to enjoy the scholarship in higher years. The number of scholarships awarded in any one year may be varied dependent upon the available funds.

Application should be made to the Office of Student Awards by May 1 on the regular admission scholarship application form.

BOILER INSPECTION AND INSURANCE COMPANY SCHOLARSHIP

The Boiler Inspection and Insurance Company of Canada offers a scholarship in the Course in Mechanical Engineering of the value of $300 to the student who obtains highest honour standing in the regular examinations of the Third Year.

The successful candidate will be expected to proceed to his Fourth Year during the session next following the date of the award.

The amount of the award will be credited by the Chief Accountant to the fees of the Fourth Year of the successful candidate.

CHEVRON STANDARD LIMITED SCHOLARSHIP

Chevron Standard Limited has presented a scholarship of $500 to a student who achieves outstanding results in the annual examinations of the Third Year in the Geophysics Option in Engineering Science or in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and Science.

The awards alternate annually between the Faculties of Applied Science and Engineering and Arts and Science and the First Award was made in the session 1960–61 in the Faculty of Applied Science and Engineering.

CARVETH METALLURGICAL LTD. BURSARY

Carveth Metallurgical Ltd. provides one or more bursaries to a total value of $500 for students entering the Third Year of Metallurgy and Materials Science. The award is made primarily on the basis of Second Year standing, but the need for financial assistance will also be taken into consideration.

The Bursary is available every third year, beginning in the Session 1961–62, and is to be awarded on the recommendation of the Department of Metallurgy and Materials Science. Application should be made by letter to the Secretary of the Faculty of Applied Science not later than September 1 of the year in which the award is tenable.

CHEMICAL INSTITUTE OF CANADA PRIZE

The Chemical Institute of Canada offers a prize of the annual value of $25 in books to the student registered in the course in Chemical Engineering who, having obtained honours, receives the highest standing in the written and laboratory work of the Third Year.

The first award was made on the results of the final examinations of 1947.

CHILDREN OF WAR DEAD (EDUCATION ASSISTANCE) ACT

Children of War Dead (Education Assistance) Act provides fees and monthly allowances for children of veterans whose death was attributable to military service. Enquiries should be directed to the nearest District Office of the Department of Veterans Affairs.

5T6 CIVILS SCHOLARSHIPS

The 5T6 Civils, consisting of the graduating members of the 1956 Civil Engineering Class of the University of Toronto, have established an annual scholarship of the value of $200 open to students who have completed the Second Year of the course in Civil Engineering and are registered in the Third Year of the course. The selection of the recipient is based on evidence of the qualities of scholarship, leadership and character. The award is not tenable with any other scholarship of greater value.

The award is presented at the annual reunion of the Class of 5T6 Civils. The first award was made in 1964.

Students who wish to be considered for this scholarship should write to the Class of 5T6 Civil Engineering, c/o Alumni House, University of Toronto, not later than

December 31, giving full particulars of their academic record, and their extra-curricular activities both within and outside the University.

COMINCO SCHOLARSHIPS

Two scholarships, of an annual value of $800 each, are provided by Cominco Limited and are offered to students in the Third Year of the courses in Chemical Engineering, Geological Engineering, Mechanical Engineering and Metallurgy and Materials Science in the Faculty of Applied Science and Engineering and to students in the Third Year of the courses in Chemistry and Geology in the Faculty of Arts and Science, the awards being made on the basis of the examination results of the Second Year. The scholarships may be renewed in the Fourth Year if satisfactory standing is maintained.

Application must be made to the Secretary of the Faculty on the regular in-course awards form not later than October 15.

CROCKER FOUNDATION BURSARIES

The income from a capital fund established from the estate of the late Beatrice Crocker Glazier in memory of her brother, James William Crocker, provides bursaries for students in the Faculty of Medicine and the Faculty of Applied Science and Engineering who are in need and are worthy of financial assistance.

Application should be made to the Secretary of the Faculty not later than October 15.

CYANAMID OF CANADA SCHOLARSHIP

As a part of their program to encourage technical development in Canada, Cyanamid of Canada Limited offers a scholarship of the value of $900 to a student entering the Third Year in Chemical Engineering or Industrial Engineering. The award is made to a student who has demonstrated high academic ability and outstanding scholarship in the work of the Second Year.

The first award at the University of Toronto was made in 1964.

PROVINCE OF ONTARIO STUDENT AWARDS PROGRAM

The Ontario Student Awards Program is intended to provide opportunities for students of this province who lack adequate financial resources to pursue post-secondary education. To be eligible to apply for assistance the student must be a Canadian citizen or landed immigrant and must have resided in the Province of Ontario for at least twelve months prior to entering the university program for which he is seeking assistance.

The program is intended to supplement rather than replace family and/or student resources. In order to determine the additional funds required the province assesses the cost of the student's education and the resources of the family and/or the student which could reasonably be applied toward the educational costs. The difference between the costs and resources, if any, is provided to the student in a combination of a loan and a free grant.

Application forms and further information may be obtained from the Office of Student Awards, Simcoe Hall, University of Toronto, from May 1 onward. Application well in advance of the commencement of the academic session is advisable. For assessment on the basis of the cost of the full session, the latest date for submission of applications is September 30.

DOW CHEMICAL OF CANADA LIMITED AWARD

Dow Chemical of Canada Limited have provided funds for an annual award of $500 to a student in Chemical Engineering in the Faculty of Applied Science and Engineering, and grant-in-aid of $250 to be used in the winner's department to help defray the cost of equipment, supplies and administration.

The winner must:

(*a*) be registered in the Third Year in Chemical Engineering (the award will be made in the second terms of the Third Year and will be paid to the winner during his Fourth Year);

(*b*) be in the upper half of the class;

(*c*) have demonstrated leadership in extra-curricular activities.

The award is not tenable with other awards in the gift of the Senate. Application is not required.

THE ELECTRICAL MANUFACTURING COMPANY LTD. – MONTEL INC. PRIZE

The Electrical Manufacturing Company Limited has established an annual Prize of $50 in the Faculty of Applied Science and Engineering.

The winner must:

(*a*) be registered in the Fourth Year in Electrical Engineering;

(*b*) obtain the highest aggregate percentage of marks at the final examinations in the subjects of the Fourth Year related to electrical distribution equipment, the subject to be determined by the Head of the Department of Electrical Engineering.

This Prize is tenable with other awards in the gift of the Senate.

THE JOHN M. EMPEY SCHOLARSHIPS

The John M. Empey Scholarship Fund was established under a bequest of $10,000 in the Will of the late John Morgan Empey, B.A.SC., 1903. Three scholarships of equal value are provided from the income from the Fund. One of these scholarships is awarded in each of the First, Second, and Third Years on the results of the annual examinations, to a student who, taking honours, obtains the highest average percentage of marks in the written and laboratory subjects of his Year. The scholarships are open to any students registered in the Faculty. In case the winner of any one of these scholarships does not attend this Faculty during the session next following the award, the right to the scholarship shall be forfeited and the award shall be made to another eligible student. The scholarships were awarded for the first time in 1944.

ENGINEERING ALUMNI ADMISSION SCHOLARSHIP

Seven scholarships, each of the value of $1000, are provided annually by the University of Toronto Engineering Alumni Association for students entering the first year of any course in the Faculty of Applied Science and Engineering. The awards are made on the basis of standing in the Ontario Grade XIII examinations.

Application should be made to the Office of Student Awards by May 1 on the regular admission scholarship application form.

ENGINEERING INSTITUTE OF CANADA PRIZE

The Engineering Institute of Canada Prize, of the value of $100, is awarded annually to a Student Member of the Institute on the basis of the marks made at the completion of his penultimate year of undergraduate study, and on his activities in the Engineering Society or in the student branch of a recognized engineering Institute or similar organization.

ENGINEERING SOCIETY SEMI-CENTENNIAL AWARD

The Engineering Society Semi-Centennial Award, to the value of $75 was established in 1931 to commemorate the semi-centennial of the founding of the "School." The award is made to a student entering the final year.

The selection is based upon the following qualifications, which bear equal weight in the selection of the winner: (*a*) General "School" activities. (*b*) Contributions to the Engineering Society Executive Committee. (*c*) Personality, and social and athletic activities. (*d*) Academic standing.

J. A. FINDLAY SCHOLARSHIPS

These scholarships were established through a legacy bequeathed by the late Miss Janet Findlay to the Department of Mechanical Engineering. Two scholarships are available, each of a value of one half of the income of the fund, to students in this Course, one for a student in the Third Year, the other for a student in the Fourth Year, but only if the student continues his course in Mechanical Engineering. The selection will be made, on recommendation of the Head of the Department of Mechanical Engineering, from amongst the four students having the highest average percentage of marks at the annual examinations in the Second and Third Years respectively, but in making the award the student's general character, fitness for his profession, and financial circumstances will be given consideration. In case a student who has been awarded one of the scholarships changes his course or does not attend this University during the next following session, he shall forfeit his right to the scholarship and the award shall be made to another eligible student.

THE JAMES FRANCESCHINI FOUNDATION SCHOLARSHIP

This scholarship, of a value of $300, is awarded to the student in Civil Engineering who achieves the highest standing, with honours, at the annual examinations of the Third Year among those who do not hold an award of a value of $100 or more based on the results of these examinations.

HUGH GALL AWARD

The Hugh Gall Award was established in 1946 by the Graduate Class of 1910 "to commemorate a deceased classmate who was a splendid type of student, a loyal friend, and nationally outstanding in athletic achievement during his undergraduate career." Upon expiration of the original gift in 1951 the award was supported by Mrs. Hugh Gall until her death in 1970; under the terms of her will a sum of $5,000 was provided to support the award in perpetuity, the annual value of the award being the income from the bequest. The award is made to a student who, having completed his First Year with a general average of at least 66% without conditions, has entered the Second Year, and is in special need of financial assistance in order to enable him to continue his course. It is desirable, but not necessary, that the recipient shall not already have been given any other scholastic award or scholarship applicable to the second year and he shall have shown indications of his firm intention and ability to follow successfully the profession of engineering.

Any second year student in the Faculty of Applied Science and Engineering is eligible to apply for this Bursary. Applications should be made to the Secretary of the Faculty not later than October 15.

THE GRABILL ADMISSION SCHOLARSHIP

The Grabill Admission Scholarship is the gift of Mr. Dayton L. Grabill, a graduate of this Faculty in 1924. The Scholarship has a value of approximately $500. It is awarded to the candidate who has standing amongst those with the highest average percentages in the subjects of Ontario Grade XIII required for admission to the Faculty of Applied Science and Engineering. The candidate must write the Grade XIII examinations at one sitting in the June preceding entry to the University after not more than one year's instruction in Grade XIII and must register in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards on the regular Admission Scholarship form by May 1.

THE REGINALD AND GALER HAGARTY SCHOLARSHIP

The Reginald and Galer Hagarty Scholarship, in memory of the dearly beloved sons of Lieutenant-Colonel E. W. Hagarty, B.A. 1883, M.A. 1908, and Charlotte Ellen Hagarty, his wife. Reginald Edward Walter Hagerty, B.A.SC. (Honours) 1908, a graduate of the University in the Faculty of Applied Science and Engineering and at the time of his death on April 29, 1925, a Consulting Structural Engineer. Lieutenant Daniel Galer Hagarty, Princess Patricia's Canadian Light Infantry, a member of the class of 1916 in Applied Science, enlisted for the Great War at the end of his third year in June, 1915, killed in action in Sanctuary Wood, June 2, 1916. The scholarship is given in recognition of the fact that their father was an honour graduate in Classics of the University of Toronto. It is of the value of the annual interest on the capital sum of $2,000 and is to be awarded to a student who has been enrolled for his Grade XIII Year at Harbord Collegiate Institute and having obtained at least the required standing in each of the Grade XIII subjects necessary for admission to the Faculty, obtains the highest standing in English, a language other than English, and Mathematics, among the students who apply for the award from the Collegiate. He will be required to: (*a*) register in the Faculty of Applied Science and Engineering, (*b*) sign a declaration to the effect that he is willing to take up arms in the defence of Canada and the British Commonwealth should necessity arise as declared by the Parliament of Canada. The Scholarship was offered for award for the first time in 1945. Application should be made to the Office of Student Awards on the regular admission scholarship application form not later than May 1.

CHESTER B. HAMILTON SCHOLARSHIP

Members of the family of the late Chester B. Hamilton, a graduate of the Faculty in 1906, have presented a Scholarship in his memory of the annual value of $500. It is held by a Fourth Year student in Mechanical Engineering who has achieved outstanding academic standing at the Annual Examinations of the Third Year.

The first award was made on the results of the examinations for the Session 1958–59.

HAMILTON WATCH AWARD

Hamilton Watch Company, Lancaster, Pa., presents a wrist watch, suitably engraved, to the Fourth Year student in the Faculty of Applied Science and Engineering who at the annual examinations attains Honour standing and who has achieved high aggregate marks during his four years in the social-humanistic subjects common to all courses.

THE MURRAY CALDER HENDRY SCHOLARSHIP

This award was established by the estate of Mrs. Grace Appel Hendry as a memorial to her husband, a graduate of this Faculty in 1905. It has a value of the income from a capital sum of $10,000 and the recipient must:

(*a*) have attained an average of at least 75% on the grade XIII examination papers, written at one sitting, required for admission to the Faculty.

(*b*) be entering the First Year of any course in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards by May 1 on the regular University Admission Scholarship Application form.

The first award was made in the Session 1962–63.

ROY JARVIS HENRY ADMISSION SCHOLARSHIPS

The estate of the late Roy Jarvis Henry provides three scholarships of the value of $500 each, to be awarded to students who have achieved high standing on the Ontario Secondary School qualifications required for admission, two of which are open to students entering any course in the Faculty and one open to students entering Geological Engineering. In the lack of a suitable candidate in Geological Engineering, all three awards are tenable in any course in the Faculty. Application must be made on the regular admission scholarship application form.

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO BURSARY

The Hydro-Electric Power Commission of Ontario has provided a bursary of the value of $500, which may be awarded to a student entering the second year of the courses in Mathematics and Physics or Commerce and Finance in the Faculty of Arts and Science, or any course in the Faculty of Applied Science and Engineering. Application should be made on the regular in-course bursary form not later than October 15.

IBM – THOMAS J. WATSON MEMORIAL BURSARY FUND

International Business Machines Company Limited has made available one or more bursaries of a total annual value of $1,000 to students registered in any year of a full time course in the university who have standing satisfactory to the committee of Award and demonstrate financial need.

Application should be made to the Office of Student Awards by October 15.

JENKINS SCHOLARSHIP

The Jenkins Scholarship, presented by Jenkins Bros., Limited, Montreal, first awarded in 1925, has been donated to continue indefinitely.

This Annual Scholarship, of the value of $200, is awarded to the student of the Third Year registered in any course of the Faculty who has the highest aggregate of percentages for the First, Second and Third Years.

JOHNSON'S WAX SCHOLARSHIP

S. C. Johnson and Son Limited, Brantford, Ontario, have established a Scholarship of an annual value of $800 in each of the Second, Third and Fourth Years or a total possible value of $2,400.

The recipient must:

(*a*) be registered in Chemical Engineering in the years in which the Scholarship is awarded and held;
(*b*) in the opinion of the Council be the most promising and deserving member of the class, obtaining Honours in the final examinations of the First Year;
(*c*) in his Second and Third Years, maintain academic standing satisfactory to the Council, not necessarily Honours, for the continued enjoyment of the Scholarship. In its discretion the Council may recommend the award of any portion of the Scholarship, lost by the original recipient by failure to maintain satisfactory academic standing, to another student of the year(s) in which the Scholarship would otherwise have been enjoyed.

The first award was made on the results of the annual examinations written in April 1954. It is not tenable with any other Scholarship.

THE LEONARD FOUNDATION SCHOLARSHIPS

Leonard Foundation Scholarships are awarded each year to selected students in Universities and Colleges across Canada, including the University of Toronto. The Trust Deed states: "Preference in the selection of students for scholarships shall be given to the sons and daughters respectively of the following: (*a*) clergymen, (*b*) school teachers, (*c*) officers, non-commissioned officers and men, whether active o retired, who have served in Her Majesty's military, naval or air forces, (*d*) graduates of the Royal Military College of Canada, (*e*) members of the Engineering Institute of Canada, (*f*) members of the Mining and Metallurgical Institute of Canada."

All applicants must be nominated by a member of the General Committee. The latest date for the receiving of applications is March 31, for the following academi year. Further information regarding the procedure to be followed in applying fo these scholarships may be obtained by writing to the Leonard Foundation, c/o Canada Permanent Trust Co., 320 Bay Street, Toronto 1.

THE J. EDGAR MC ALLISTER FOUNDATION

Through the generosity of the late J. Edgar McAllister, a graduate of the Faculty i 1891, a fund has been established in the University to be known as the J. Edga McAllister Foundation, to provide financial aid for students who require it, in Mechanical, Chemical, Electrical and Metallurgy and Materials Science. Inquiries shoul be made in the Faculty Office.

THE JOHN WOLFE MC COLL MEMORIAL AWARDS

These six awards, two of which are open to students in the Faculty of Applied Scienc and Engineering, are the gift of the estate of the late John Wolfe McColl. The award have a minimum value of $250 and a maximum of $750. Applicants must hav obtained First Class Honours at the final examinations of the preceding year, whethe Ontario Grade XIII or at the University of Toronto, demonstrate financial need an be enrolled or undertake to enrol in either Engineering Science or Chemical Engineering. Students seeking first admission to the University must submit applications for an award to the Office of Student Awards on or before May 1. Students in the University must submit applications for an award to the Registrar of the University on or before October 15.

THE J. A. D. MC CURDY PRIZE

The J. A. D. McCurdy Prize of a value of $75 was established by the trustees of a fund created by the members of the Number 3 Squadron, University Air Training Corps (1941–44) in honour of John Alexander Douglas McCurdy, a graduate of the School of Practical Science, who "made the first flight in Canada on February 23, 1909, with a heavier-than-air machine."

It is awarded annually to the student registered in Third Year, Aeronautics Option, in Engineering Science, who, taking honours, ranks highest in annual examinations of the Third Year in the subjects related to Aerodynamics.

The first award was made on the results of the examinations of the Session 1953–54.

THE GARNET W. MCKEE-LACHLAN GILCHRIST SCHOLARSHIP IN ENGINEERING SCIENCE

Mrs. Garnet W. McKee and Professor Lachlan Gilchrist each contributed $1,000 to provide for a Scholarship in the First Year of the Course in Engineering Science. The value of the Scholarship is the annual income from the capital fund and is awarded to the student who ranks first in honours at the annual examinations of the First Year in the Course in Engineering Science. If for any reason that student is ineligible to hold the Scholarship, it will be awarded by reversion to the student ranking second in honours in the Course. In order to receive payment the winner must register in the Second Year of the Course in Engineering Science. The Scholarship was awarded for the first time on the results of the annual examinations of 1947.

THE GARNET W. MC KEE-LACHLAN GILCHRIST GEOPHYSICS SCHOLARSHIPS

Financial assistance was received by Professor Lachlan Gilchrist of the Department of Physics, University of Toronto, from certain organizations and individuals to help him in the prosecution of his research work in Geophysics. With the consent of the contributors, the unexpended balance of these gifts was transferred by Professor Gilchrist to the Board of Governors of the University to be used as an endowment for scholarships, two of which were established in the Faculty of Applied Science and Engineering. To this fund have been added additional amounts received from the estate of the late Garnet W. McKee and from the Hollinger Consolidated Gold Mines Ltd. They are awarded by the Senate, on the recommendation of the Council of the Faculty of Applied Science and Engineering. The first awards were made on the results of the Annual Examinations of 1941.

The First Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $200 is awarded to the student in the Second Year in the Course of Engineering Science who obtains the highest aggregate standing at the examinations of the First and Second Years in the Course, provided always that the student obtains honour standing at the examinations of the Second Year.

The Second Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $165 is awarded to the student in the Second Year in the Course of Engineering Science who, of those students who elect to proceed in the Third Year in the Geophysics Option of the Course, obtains the highest aggregate standing at the examinations of the First and Second Years, provided always that the student obtains honour standing at the examinations of the Second Year, and excluding always the student to whom the First Lachlan Gilchrist Geophysics Scholarship has been awarded.

If in any year there is no student who has fulfilled the condition as laid down for the Second Lachlan Gilchrist Geophysics Scholarship, it shall be awarded to the student in the Second Year in the Course in Engineering Science who obtains the second highest aggregate standing at the examinations of the First and Second Years of that Course, provided always that such student obtains honour standing in the examinations of the Second Year.

LACHLAN DALES MC KELLAR ADMISSION SCHOLARSHIPS

Provided by a bequest of the late Leona D. McKellar, two scholarships of the value of $500 each, are offered to students who have achieved high standing on the Ontario Secondary School qualifications required for admission to the Faculty. Application must be made on the regular admission scholarship application form.

THE ALEXANDER MAC LEAN SCHOLARSHIP

This scholarship was established by graduates of the University of Toronto and other friends in honour of Professor Alexander MacLean, B.A. (1908) who retired in 1954 The scholarship, of the value of $250, is awarded to a student in the Third Year o Geological Sciences, Faculty of Arts, or in the Third Year of Geological Engineering Faculty of Applied Science and Engineering, who, obtaining not less than 75% in the work of the year, obtains the highest standing in the geological subjects common to the two courses.

The first award was made in 1955.

MAC LENNAN-MAC LEOD MEMORIAL PRIZE

The Graduating Class of 1910 has donated an annual prize, known as "The Mac Lennan-MacLeod Memorial Prize," in memory of their first Class President, George MacLennan, who was killed in action in France in 1917, and of Doug. MacLeod, thei first Secretary, who died in France in 1916 from wounds received in action.

The prize, of the value of $25, is awarded to the First Year student in the Faculty of Applied Science and Engineering who ranks highest in Calculus among those who obtain standing without condition at the annual written examinations; or, in the event of more than one student obtaining equally high rank in Calculus, the award is made to the one of these who also has the highest standing in some other subject common to the competitors, such as Analytical Geometry, such subject to be determined by the Council of the Faculty.

An award will not be made in any year in which, in the opinion of the Council, no student obtains a sufficiently high standing in Calculus to merit the award. If in any year no award is made, a second award will be available in the subsequent year.

CHARLES GORDON MANNING PRIZE

The Charles Gordon Manning Prize was established by a bequest under the Will of the late Jennie Manning in the amount of $500, the annual income from which is to be used to buy books for the winner of the Prize.

The recipient must be enrolled in the Second Year of a course offered by the Faculty of Applied Science and Engineering and, in the opinion of the Council, rank second to the student awarded the Harvey Aggett Memorial Scholarship in the considerations specified for the award of that Scholarship, namely, obtaining honours in his final examinations and being one of the first three in his year by his standing at those examinations relative to the pass requirements in his Department and being "adjudged highest of the three in general student activities and service in the University during his period of attendance."

The first award was made on the results of the annual examinations of 1954.

MARSLAND ENGINEERING LIMITED SCHOLARSHIP

The Marsland Engineering Limited Scholarship, the gift of Marsland Engineering Limited, has a value of $250. It is awarded to the student who, having been granted a Dominion-Provincial Student Aid Bursary in his First Year, is registered in Mechanical or Electrical Engineering and obtains the highest average percentage of marks, with honours, at the annual examination of the First, Second or Third Years in the session in which the award is made.

The first award was made at the annual examinations of 1954.

MASSEY-FERGUSON LIMITED SCHOLARSHIPS

Massey-Ferguson Limited has established two scholarships each of an annual value of $250, to be awarded on the recommendation of the Council of the Faculty of Applied Science and Engineering to students registered in the Fourth Year of the Courses in Mechanical Engineering or Industrial Engineering. In making the award academic achievement, financial need, extra-curricular activities and such other factors as may be deemed appropriate will be taken into consideration.

Application should be made to the Secretary of the Faculty not later than October 15.

GEORGE R. MICKLE ADMISSION BURSARIES

Provided for by a bequest of the late George R. Mickle, five bursaries of the value of $1000 each are available to students entering the First Year of courses in the Faculty of Applied Science and Engineering. The awards are made on the basis of the applicant's academic standing in Grade XIII, and his need for financial assistance. Applicants wishing to be considered for these awards should complete the financial need section on the regular University of Toronto admission awards application form.

JAMES L. MORRIS MEMORIAL PRIZE

The James L. Morris Memorial Prize is the gift of Mrs. J. H. Craig and Mr. J. R. Morris, K.C., in memory of their father, James L. Morris, C.E., O.L.S., D.Eng., the first graduate of the School of Practical Science, who died in 1946 after a distinguished career. Graduating in Civil Engineering in 1881 as the sole member of his class, Dr. Morris engaged in railway work for some time, first as an engineer and then as a contractor. For 43 years he conducted a successful civil engineering practice in Pembroke, Ontario, involving important undertakings in the field of municipal power and bridge work.

This Prize, of the value of the annual income from $3,000, is awarded annually to the student in the Second Year of the Course in Civil Engineering who obtains the highest aggregate percentage at the annual examinations of the First and Second Years of the course, provided always that the student obtains honour standing at the Examinations of the Second Year.

OTTO HOLDEN SCHOLARSHIP

Otto Holden, B.A.Sc., C.E., D.Eng., was a distinguished hydraulic engineer of international reputation. He served Ontario Hydro for 47 years and retired as Chief Engineer in 1960, having been involved in almost all of the major hydro-electric developments in Ontario. On his death Mr. Holden left a sum of money which was later augmented by his widow, the late Florence Holden, to establish a scholarship in the Faculty of Applied Science and Engineering. This scholarship, which has a value of approximately $750 is awarded to the student who, completing the Fourth Year in Civil Engineering or Mechanical Engineering with Honours, obtains the highest aggregate marks in hydraulic engineering subjects in the Third and Fourth Years of the course. The first award was made in the session 1967–68.

THE ONTARIO HOCKEY ASSOCIATION WAR MEMORIAL SCHOLARSHIP

The Ontario Hockey Association War Memorial Scholarship, the gift of the Ontario Hockey Association, is to be awarded annually at the Grade XIII examination to an applicant whose father served overseas with the Canadian Forces in World War I

The value of this scholarship is $100 in cash, with an allowance of the same amoun on the tuition fee for each session.

In determining the award of the scholarship, the academic qualifications of the candidate shall be first taken into account, provided always that no candidate shall be eligible for an award who has not met all the conditions required by the University of candidates for admission scholarships generally; but *cæteris paribus*, the award shall be made to a student who is in proved need of assistance.

The award shall be made by the Senate of the University upon the report of a committee to be appointed by the Senate, upon which committee there shall be always one member of the Staff of the University who shall be deemed to be representative of the Association.

Application should be made to the Office of Student Awards on the regular scholarship application form not later than May 1.

PAULIN MEMORIAL SCHOLARSHIP

The Paulin Memorial Scholarship, provided through the generosity of the late Mr. Fred W. Paulin, a graduate of this Faculty in 1907, was established in memory of his brother, John Cameron Paulin, a student of this Faculty, who was fatally injured in 1906 during a football practice. The scholarship, which has the value of the income from a capital fund of $10,000, approximately $550 annually, is awarded to a student who obtains high standing in the work of the first year in the Faculty of Applied Science and Engineering.

PROCTER AND GAMBLE BURSARY PLAN

Procter and Gamble Bursaries, the gift of the Procter and Gamble Company of Canada, are awarded annually to students in all years. Applicants must have at least Second Class Honours or better in the final examinations of the preceding year and demonstrate financial need. Applications must be submitted to the Office of Student Awards on or before December 1.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO ADMISSION SCHOLARSHIP

The Ontario Professional Engineers Foundation for Education provides an admission scholarship of the value of $500. It is awarded to the candidate who obtains the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to the Council that his attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other Admission scholarship.

Application must be made to the Office of Student Awards before May 1.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO SCHOLARSHIPS

The Ontario Professional Engineers Foundation for Education offers scholarships of a value of $250 in each of the First, Second and Third Years in the Faculty of Applied Science and Engineering in any course, to the students who, taking Honours, obtain the highest standing in the work of their respective years.

These scholarships will not be awarded to students who hold other scholarships.

PROFESSIONAL ENGINEERS GOLD MEDAL

The Association of Professional Engineers of the Province of Ontario has established in the Faculty of Applied Science and Engineering an award in the form of a gold medal accompanied by a gift of technical books of an approximate value of $50. The award will be made to the student of the final undergraduate year in any course who, taking honours, obtains the highest weighted average percentage in the practical work and written examinations of the year.

RANSOM SCHOLARSHIP IN CHEMICAL ENGINEERING

The Ransom Scholarship in Chemical Engineering is presented by A. C. Ransom, Esq., of Toronto, for the purpose of encouraging and giving financial assistance to students who choose the field of Chemical Engineering. This donation, consisting of $5,000, provides for a perpetual scholarship of an annual amount such as will be derived from the income of this sum. The first award was made on the results of the annual examinations of 1938.

The scholarship will be awarded annually to the student registered in the Course in Chemical Engineering who obtains the highest aggregate percentage of marks in the examinations of the First Year. The scholarship will be paid to the winner only if he proceeds to take his Second Year in the Course in Chemical Engineering in the University of Toronto.

J. E. REID MEMORIAL PRIZE

This prize, established in 1967 in memory of the late Professor J. E. Reid, is awarded to the student in the Fourth Year of the course in Electrical Engineering who, graduating with honours, achieves the highest aggregate marks in the Fourth Year examinations in the subjects pertaining to electronic communication.

THE RHODES SCHOLARSHIPS

The Rhodes Trustees offer for award in the Province of Ontario two out of ten of the Rhodes Scholarships for Canadians, each of the value of £1,000 and tenable at Oxford University for a period of two years; in certain cases, a third year may be authorized.

Each candidate must be a British subject with at least five years domicile in Canada and unmarried; he must have passed his nineteenth but not twenty-fifth birthday on October 1 of the year *for* which he is elected; he must have completed the first year of his course at a Canadian university at the time of application.

A candidate may apply either for the province in which he has his private home or residence, or for the province in which he has taken his university course.

In that section of the will in which he defined the general type of scholar he desired, Mr. Rhodes mentioned four groups of qualities, the first two of which he considered most important.

(1) Literary and scholastic attainments;
(2) Qualities of manhood, truth, courage, devotion to duty, sympathy, kindliness, unselfishness, and fellowship;
(3) Exhibition of moral force of character and of instincts to lead and to take an interest in his fellows;
(4) Physical vigour, as shown by fondness for and success in outdoor sports.

Some definite quality of distinction, whether in intellect, character or personality, or in any combination of these, is the most important requirement. Financial need does not receive special consideration.

Forms of application and full information regarding these scholarships may be obtained from the Registrar, University of Toronto, or from J. L. Stewart, Esq., General Secretary for the Rhodes Scholarships in Canada, 14th floor, 320 Bay St., Toronto 1. Selection is made in December for the following year and all applications must reach the provincial secretary before November 15 annually.

R.C.E. MEMORIAL SCHOLARSHIP

The Memorial Fund Committee of the Royal Canadian Engineers has established the R.C.E. Memorial Scholarship of a value of $125, open to students who have successfully completed their second to last year in the Faculty of Applied Science and Engineering or the School of Architecture.

A candidate must be:

(*a*) a member in good standing of the Canadian Officers Training Corps and have successfully completed one summer season's training, or

(*b*) an ex-member of the Canadian Officers Training Corps who has successfully completed two years of C.O.T.C. Training and has transferred to the Canadian Army (Militia) or to the Canadian Army (Supplemental Reserve), or

(*c*) a member of the Canadian Army (Regular) attending University under the Regular Officers Training Plan.

Selection is made on the basis of academic standing and of qualities of leadership.

Application forms may be obtained from the Office of Student Awards.

REGULAR OFFICER TRAINING PLAN

Tenable in approved degree courses, this plan is available to Canadian citizens who undertake to serve in the armed forces for at least four years after graduation. Accepted candidates will receive tuition, a book allowance of $125 and a living allowance of $193 per month during the academic session.

Application should be made to the Canadian Forces Recruiting Centre, 25 St. Clair Avenue West, Toronto 7.

HELEN E. ROGERS ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of Helen E. Rogers open to students entering any degree course in the University. Preference is given to applicants from outside Ontario but failing such candidates awards may be made to qualified Ontario students. Recipients must have a standing satisfactory to the Committee of Award on first admission and may continue to enjoy the scholarship in the upper years provided they maintain first class standing. The value in each year is a minimum of $200 and a maximum of $1,500 dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards by May 1 on the regular admission scholarship application form.

DON SALT MEMORIAL SCHOLARSHIPS

In memory of Donald John Salt, a graduate of the Faculty of Applied Science and Engineering and a practising geophysicist, the Canadian Exploration Geophysical Society has provided two scholarships of the value of $500 which are open to students in the Third and Fourth Years of certain courses in the Faculty of Arts and Science, and in Geological Engineering and the Geophysics option of Engineering Science in the Faculty of Applied Science and Engineering.

The award is made on evidence of the interest and ability of the applicant in relation to the field of mining geophysics.

Application should be made either to the Chairman of the Department of Physics or the Chairman of the Department of Geology by March 1 in the calendar year in which the award is to be made.

ROSEDALE CHAPTER I.O.D.E. AWARD IN ENGINEERING SCIENCE

An award of $400 will be made annually to a student enrolled in the Third Year of the program in Engineering Science, on the basis of academic standing and financial need. Recipients must be Canadian citizens, but not necessarily residents of Ontario.

Application should be made to the Secretary of the Faculty on the regular in-course bursary application form not later than October 15.

FREDERICK W. SCHUMACHER SCHOLARSHIP

The Frederick W. Schumacher Scholarship has been awarded in the Faculty of Applied Science and Engineering and in the Faculty of Arts under a bequest of the late Frederick W. Schumacher. It has a value of the income from the fund. The scholar must (*a*) be enrolled in the Second, Third or Fourth years in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and (*b*) must have high academic standing.

Applications must be submitted to the Office of Student Awards not later than October 15.

"SECOND MILE ENGINEER" AWARD

The Class of 3T5, convinced that a successful engineer must not only be professionally competent but also constantly aware of his responsibilities to humanity, and inspired by an address of President William E. Wickenden of the Case School of Applied Science, Cleveland, called "The Second Mile," which was based on the text from the Sermon on the Mount, "whosoever shall compel thee to go one mile, go with him twain" has established the "Second Mile Engineer" award. It is the desire of the donors to encourage undergraduates to participate fully in extra-curricular activities and to recognize the true importance of the more liberal subjects of the curriculum with the ultimate objective, on entering the profession, of becoming worthy Second Mile Engineers. The award comprises a grant of $200, a suitably inscribed presentation piece and an illuminated scroll, and is presented to a student in his final year.

An eligible group is chosen from those who have taken a prominent part in the affairs of the Faculty, either as office holders or in athletics. In making the award consideration is given to academic standing, with special emphasis on the candidate's attainments in the cultural and humanistic-social studies.

Particulars are furnished each session by the Class of 1935.

THE SIMPSONS-SEARS LIMITED (NORTHERN ONTARIO) SCHOLARSHIPS

These scholarships, the gift of Simpsons-Sears Limited, are open only to students of the Copper Cliff High School, The Sudbury High and Technical Schools, the Sturgeon Falls High School, the North Bay Collegiate Institute and Vocational School, the Kapuskasing High School and all the Secondary Schools along the Ontario Northland Railway. A scholarship of the value of $100 is available for each of the schools mentioned and an additional sum of $50 will be given to the student who obtains the highest percentage of the nine papers of Grade XIII selected in accordance with the regulations.

No scholarship will be awarded unless the candidate is in actual attendance in one of the colleges or faculties of the University and maintains a uniformly high standard to the satisfaction of the donors of the scholarships.

Application for these scholarships must be sent not later than May 15, to the Principal, Algonquin Composite School, North Bay, from whom further information may be obtained regarding conditions of award.

WALLACE AWARD
SOCIETY OF AUTOMOTIVE ENGINEERS PRIZE

In memory of William Wallace, Professor of Mechanical Engineering, University of Toronto, the Ontario Society of Automotive Engineers offers an annual prize of the value of $100 to a student of the Fourth Year in any course whose thesis on a topic related to Automotive Engineering is considered by the Head of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory.

SOCIETY OF CHEMICAL INDUSTRY MERIT AWARD

The Society of Chemical Industry Merit Award is made annually by the Society to the student in Fourth Year in the Department of Chemical Engineering who obtains the highest weighted average of marks in the results of the annual examinations for the year. The award is a gold key.

THE MURRAY F. SOUTHCOTE SCHOLARSHIP

Established by friends of the late Murray F. Southcote, a graduate of this Faculty (Aeronautical Engineering, 1950) this scholarship, which has a value of $100, is awarded in recognition of high standing at the Annual Examinations of the Third Year, in any course in the Faculty.

The first award was made in the Session 1964–65.

WALTER STERLING ADMISSION SCHOLARSHIPS

Established in memory of Walter Sterling, these scholarships are open to students entering any first degree course at the University of Toronto. Recipients must obtain First Class Honours standing on the nine Ontario Grade XIII papers required for admission, and may continue to enjoy the scholarships in each year of their course providing they maintain Honour standing. The value of the scholarship is from $200 to $1,500 annually, dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards on the regular scholarship application form. The statement of financial need should be completed if an award greater than $200 is desired.

C.H.E. STEWART BURSARIES

Under the provisions of the will of the late Mary Jones Stewart a sum of $10,000 was bequested to the University, the income of which is to be used to provide a number of bursaries in denominations of $50, $75 and $100 to students in the Third and Fourth Years of courses in the Faculty of Applied Science and Engineering, the awards to be made on the basis of financial need, scholastic ability and general character, with preference being given to students who are descendants of veterans of the First and Second World War. Applications should be submitted to the Secretary of the Faculty by October 15, on the regular in-course bursary application form.

EDITH TYRRELL MEMORIAL BURSARY

The Women's Association of the Mining Industry of Canada has presented this Bursary, having the value of $600, annually, commencing in 1939, and named in memory of their founder and first president, Mrs. Edith Tyrrell. A medal donated by Dr. Tyrrell accompanies this Bursary. The Bursary is awarded to a student entering the Third or Fourth Year in the Course of Metallurgy and Materials Science, or Geological Engineering; it may be awarded two years in succession to the same student, but will usually be awarded at the beginning of the Third Year. The award will be made by a special committee appointed by the Association on the following basis:

(*a*) In addition to mental capacity, the student must show leadership ability and give promise, through his activities, of becoming a worthwhile influence in the affairs of the profession and the community.

(*b*) While attention is given to scholastic ability, as evidenced by his academic standing, it is not the governing factor. He must, however, stand in the top quarter of his class.

(*c*) Special consideration is given to financial need.

Application must be made to the Secretary of the Faculty within one month of the opening of the academic year.

S. UBUKATA FUND

The S. Ubukata Fund for Japanese students was established to assist students from Japan proper to pursue a course of study at the University of Toronto. The fund provides grants of varying values on the basis of the information submitted by the applicants who:

(*a*) must be Japanese students from Japan proper;
(*b*) must register in the University of Toronto devoting full time to their studies;
(*c*) are able to satisfy admission requirements regarding English facility;
(*d*) are not holding other financial aid.

UNIVERSITY OF TORONTO ALUMNI ASSOCIATION WAR MEMORIAL SCHOLARSHIPS

Six scholarships are awarded annually by the University of Toronto Alumni Association to students entering first degree courses at the University of Toronto. The scholarships have a value of $500 annually, and are tenable for two years, providing satisfactory academic standing is maintained. They are awarded for general proficiency in Grade XIII, and in addition to academic performance the committee of award will take into consideration the candidate's relationship to active service in the Armed Forces of Canada, need of financial assistance, participation in extra-curricular activities and such other qualifications as may commend themselves to the committee. One scholarship will be available to a student whose home is not in the Province of Ontario.

Students resident in Ontario may apply on the general admission scholarship form which must be submitted to the Registrar of the University not later than May 1. Evidence of relationship to active service in the Armed Forces of Canada should be attached. Students resident outside Ontario may obtain the necessary forms from the Office of Student Awards, University of Toronto.

THE U.T.S. ENGINEERING SCHOLARSHIP

The U.T.S. Engineering Scholarship, the gift of R. A. Bryce, Esq., of the value of $250. The scholarship will be awarded by a committee of the Staff of the University of Toronto Schools to a student of the Schools who has completed the requirements for admission to and enrols in the Faculty of Applied Science and Engineering.

WALLBERG ADMISSION SCHOLARSHIPS

Two admission scholarships, each of a value of $500 are awarded annually from the income from the Wallberg Bequest on the recommendation of the Council of the Faculty to the two candidates who obtain the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to Council that this attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other Admission scholarship.

Applications must be submitted to the Office of Student Awards on the prescribed form by May 1.

WALLBERG UNDERGRADUATE SCHOLARSHIPS

These scholarships, four in number, of the value of $500 each, derived from the Wallberg Bequest, are awarded annually; two to students ranking first and second respectively at the annual examinations of the First Year; one to the student ranking first at the annual examinations of the Second Year; and one to the student ranking first at the annual examinations of the Third Year.

Any holder of one of these scholarships may not hold other awards listed in the index with an asterisk. The awards were first made on the result of the annual examination of 1947.

W. S. WILSON MEDALS

These medals have been provided in recognition of the service to the Faculty of Applied Science and Engineering of its former Assistant Dean and Secretary, William Stewart Wilson.

A medal will be awarded to the student in each graduating course, who, attaining Honours, achieves the highest standing in the final year of his course.

The first awards were made in the Session 1962–63.

WILLIAM R. WORTHINGTON MEMORIAL SCHOLARSHIP

The William R. Worthington Memorial Scholarship, the gift of Miss Ida R. Worthington, in memory of her brother, William R. Worthington, DIP.(1904), B.A.SC.(1905), of the value of the income from a fund is awarded annually to the student of the Second Year in the course in Civil Engineering who ranks highest at the annual examinations of that year.

The first award was made at the examinations for the Session 1954–55.

LOAN FUNDS

From the loan funds mentioned below, small loans can be made to students who are in urgent need of assistance. The funds are not large and the loans must accordingly be restricted, both in amount and number, and principally to students in the Third and Fourth Years.

Inquiries for loans from any of the following funds should be made at the office of the Secretary of the Faculty.

Engineering Society Loan Fund
Elizabeth Speller Memorial Fund
James W. Crocker Memorial Fund
Harry F. Bennett Educational Fund
S.A.E. – Canadian Section Loan Fund
Avro Aircraft Limited Engineering Loan Fund
The William Storrie Memorial Fund
3T6 Engineers Loan Association
4T0 Engineering Loan Fund
The Devonshire Loan Fund
Class of '09 Trust Fund
University of Toronto Alumni Loan Fund
Wallberg Memorial Loan Fund

CLASS OF 1936 LOAN ASSOCIATION

Members of the Class of 1936 have made arrangements to assist students in obtaining loans through regular banking facilities. Information may be obtained from the Secretary of the Faculty.

ENGINEERING SOCIETY LOAN FUND

In 1932 the Engineering Society repaid to the Board of Governors a series of annual grants which, over a period of years, had been made to the Society for special purposes. The Board of Governors, appreciating this action, set aside this sum, to be known as the Engineering Society Loan Fund, to provide loans to students of the Faculty of Applied Science and Engineering. The administration of the fund is carried out by a Committee appointed by the Board. The fund is not large, and only small loans can be made to relatively few students. Further inquiries should be made at the office of the Secretary of the Faculty.

ELIZABETH SPELLER MEMORIAL FUND

Through the generosity of Dr. F. N. Speller, of the Class of 1893, the "Elizabeth Speller Memorial Fund" has been established to provide loans for worthy students of the Third and Fourth Years of this Faculty. Applications for loans from this Fund should be made to the Secretary of the Faculty.

JAMES W. CROCKER MEMORIAL LOAN FUND

This fund was established by Mrs. William Crocker in memory of her son, James W. Crocker, a graduate in Mining Engineering in 1938, who was killed in an accident in a mine in the same year.

HARRY F. BENNETT EDUCATIONAL FUND

This fund was established by subscription from members of The Engineering Institute of Canada in memory of the late Harry F. Bennett, M.E.I.C., who for six years prior to his death in 1946 was chairman of the Institute's Committee on the Training and Welfare of the Young Engineer, and who accomplished so much in this field by untiring efforts.

One purpose of the fund is to make loans to deserving students who need financial assistance to enable them to study engineering sciences at university level, and who have proved themselves by successfully completing their first year in engineering or the equivalent.

Loans will be made largely on the basis of character and to men who seem likely to develop the high professional standards which are essential to leadership in engineering science. A student who has been aided by this fund should feel that high obligations are placed on him; obligations to the subscribers, to the trustees, and to those coming after him who in turn can receive help as his loan is repaid.

Application forms may be obtained at the Faculty Office. The regulations are simple and the application of any worthwhile student will be given immediate and careful attention.

SOCIETY OF AUTOMOTIVE ENGINEERS – CANADIAN SECTION LOAN FUND

The Society of Automotive Engineers – Canadian Section has established a loan fund of $1,200 in the Faculty of Applied Science and Engineering. Preference is given to students in good scholastic standing and engaged in studies relative to the automotive and aircraft industries, and to students in fourth, third and second years in that order. Particulars may be obtained from the Secretary of the Faculty.

AVRO AIRCRAFT LIMITED ENGINEERING LOAN FUND

Avro Aircraft Limited has established a Loan Fund of $3,000 to provide loans to engineering students requiring financial assistance. Application should be made to the Secretary of the Faculty.

THE WILLIAM STORRIE MEMORIAL FUND

The William Storrie Memorial Fund has been established by Mrs. William Storrie to provide loans to undergraduates in the course in Civil Engineering. Application should be made to the Secretary of the Faculty.

THE DEVONSHIRE LOAN FUND

This fund has been established by Graduates and friends of Devonshire House to assist students in the Residence. Application should be made to the Office of the Dean of Devonshire House.

CLASS OF '09 TRUST FUND

The Class of '09 on the 50th Anniversary of their graduation made a sum of money available in the Faculty for financial aid to undergraduates, with preference to Second Year students. Inquiry should be made to the Secretary of the Faculty.

THE UNIVERSITY OF TORONTO ALUMNI LOAN FUND

This fund comes from subscriptions received originally in 1919 and in succeeding years from graduates of the University and is administered by the University of Toronto Alumni Association.

Loans are available to undergraduate and graduate students enrolled in a full time course at the University, in second and subsequent years.

Particulars may be obtained from The University of Toronto Alumni Association, Alumni House, Willcocks Street, Toronto.

IX Discipline

A SUMMARY OF THE REGULATIONS OF THE CAPUT CONCERNING STUDENT DISCIPLINE

1. Subject to the general regulations of the Caput of the University regarding jurisdiction in matters of discipline the Council of University College, the governing bodies of the Federated Universities and Affiliated Colleges, and the Councils of the Faculties, Schools, and Institutes have disciplinary jurisdiction over the conduct of all students registered in these Divisions of the University in all matters of local or internal concern to these Divisions. Jurisdiction over the conduct of students while in residence regardless of the Division of the University in which they are registered is vested in the body administering the residence.

2. Jurisdiction concerning conduct likely to affect the interests of the University as a whole is vested in the Caput.

3. The Students' Administrative Council will be supported in the proper performance of all its obligations and duties as provided in its Constitution.

4. Where the appropriate body exercising disciplinary jurisdiction has found that a student of the University has engaged in conduct prejudicial to the interests of the University, the Caput may, in its discretion, suspend or expel such student from the academic privileges of the University. Every decision of the Caput involving the expulsion of a student from the University requires confirmation of the Board of Governors.

5. Any student who interferes with the personal liberty of another or who subjects another student to indignity or personal violence may be considered by the Caput or any other body exercising disciplinary jurisdiction in the University to have committed a breach of discipline.

6. Initiation ceremonies involving physical violence, personal indignity, interference with personal liberty, or destruction of property, may be deemed a breach of discipline by the Caput or any other body exercising disciplinary jurisdiction in the University.

7. Without limiting the disciplinary powers vested in the respective bodies exercising disciplinary jurisdiction as set forth in sections 1–7, the following are cited as illustrations of conduct which, in the past, has been considered a breach of discipline prejudicial to the interests of the University:

(i) The organising of a parade on the streets of the city or the taking part in such a parade without permission of the authorities.

(ii) The destruction or defacing of University property, raids on Residences or other University buildings, and the breaking into University buildings.

(iii) Rowdy and other forms of behaviour, either on or off the Campus, of such an objectionable nature as to bring the University into public disrepute.

8. Student Clubs and Associations

(a) The constitution of every society or association of students in the University and all amendments to such constitutions require to be approved by the relevant University authorities. The giving of approval, and the responsibility for the programs of student societies and associations, shall rest as follows:

(i) With the authorities of the College, Faculty or School concerned where the membership of the student society or association is drawn from a single College, Faculty or School.

(ii) With the Board of Stewards of Hart House, where the student society or association is a Committee of Hart House and is controlled by the Board of Stewards of Hart House.

(iii) With the Caput, in the case of all other student societies and associations.

(b) No approval will be given by any of the authorities listed in (a) above to the constitution of any society or association of students if that constitution permits:

(i) Membership in the society or association to persons who are not students of the University, unless in the case of the societies listed in (a) (ii) above, where membership is open also to graduates of the University and members of the Faculty of the University.

(ii) Any action of discrimination based upon race, religion, or colour.

9. The name of the University is not to be used in connection with a publication of any kind without permission of the Caput.

X Professores Emeriti

PROFESSORES EMERITI

E. A. Allcut, M.SC.(BIRM.), M.E., F.R.AE.S.,
Professor Emeritus of Mechanical Engineering

W. B. Dunbar, B.A.SC.,
Professor Emeritus of Engineering Drawing

C. E. Helwig, M.A.SC.,
Professor Emeritus of Civil Engineering

P. B. Hughes, B.SC.(MCG.), D.ENG.(EMBRY RIDDLE)
Professor Emeritus of Mechanical Engineering

K. B. Jackson, B.A.SC., D.SC.(WATERLOO),
Professor Emeritus of Applied Physics

G. R. Lord, B.A.SC., S.M.(M.I.T.), PH.D.
Professor Emeritus of Mechanical Engineering

O. J. Marshall, B.A.SC., C.E., O.L.S.,
Professor Emeritus of Civil Engineering

W. G. McIntosh, B.A.SC.,
Professor Emeritus of Mechanical Engineering

J. W. Melson, B.A.SC.,
Professor Emeritus of Surveying and Geodesy

C. F. Morrison, B.E.(SASK.), M.SC.(MCG.),
Professor Emeritus of Civil Engineering

L. M. Pidgeon, M.B.E., B.SC.(OXON.), PH.D.(MCG.), F.R.S.C.,
Professor Emeritus of Metallurgical Engineering

E. A. Smith, M.A.(MCM.),
Professor Emeritus of Chemical Engineering

V. G. Smith, B.A.SC.,
Professor Emeritus of Electrical Engineering

G. F. Tracy, B.A.SC., S.M.(M.I.T.),
Professor Emeritus of Electrical Engineering

A. Wardell, B.A.SC.,
Professor Emeritus of Engineering Drawing

W. J. T. Wright, M.B.E., B.A.SC., B.A.,
Professor Emeritus of Engineering Drawing

XI Administrative Officers

1970–71

THE UNIVERSITY

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Director of the Office of Research Administration: Miss S. Dymond, B.A., Q.C.

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Executive Assistant to the Vice-President and Registrar, and Assistant Secretary of the Senate: W. Kent, M.A.

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Secondary School Liaison Officer: W. A. Hill
Director of Statistics and Records: J. M. Tusiewicz, B.SC.(ENG.), M.A.SC., M.B.A.

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G. E. Wodehouse, M.C., M.D., F.R.C.P.(C), M.R.C.P.
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Director of Career Counselling and Placement Centre: D. Currey, B.A.SC.
Director of International Student Centre: Mrs. K. Riddell, B.A.
Director of the Advisory Bureau: D. J. McCulloch, B.A., M.D., D.PSYCH., F.R.C.P.(C)
Director of Housing Service: Mrs. M. G. Jaffary, B.A.

Director of University of Toronto Press: M. Jeanneret, B.A., LL.D.

Director of Information: K. S. Edey
Director of Alumni Affairs: J. W. Duncanson, B.A.
Director of Development: R. L. Jones

Warden of Hart House: E. A. Wilkinson, B.A.
Acting Director of Athletics and Acting Director of the Department of Athletics and Recreation–Men: A. D. White, B.A., M.ED.
Director of the Department of Athletics and Physical Education–Women
Miss A. Hewett, B.ED., P.E.

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The University of Toronto issues the following calendars and other publications detailing courses of instruction given by the University. Requests for calendars or information may be directed to the Office of Admissions of the University or to the Secretary of the particular Faculty, School or Institute.

ADMISSION INFORMATION:	Admission Awards Undergraduate Admission Handbook Undergraduate Admission Bulletin
APPLIED SCIENCE AND ENGINEERING:	Faculty of Applied Science and Engineering Engineering at Toronto – descriptive brochure
ARCHITECTURE:	Faculty of Architecture, Urban and Regional Planning and Landscape Architecture
ARTS AND SCIENCE:	Faculty of Arts and Science – St. George Campus Scarborough College Calendar Erindale College Calendar
BUSINESS:	School of Business – Graduate Programmes in Business Administration
CHILD STUDY:	Institute of Child Study
DENTISTRY:	Faculty of Dentistry Division of Postgraduate Dental Education Division of Dental Hygiene
EDUCATION:	The College of Education Graduate Degrees in Education*
EXTENSION:	Degree Programmes in Extension Diploma and Certificate Programmes in Extension Continuing Education Programme in Extension
FOOD SCIENCES:	Faculty of Food Sciences
FORESTRY:	Faculty of Forestry
GRADUATE STUDIES:	School of Graduate Studies
HYGIENE:	School of Hygiene
LAW:	Faculty of Law
LIBRARY SCIENCE:	School of Library Science
MEDICINE:	Faculty of Medicine, Medical Course Division of Rehabilitation Medicine Division of Postgraduate Medical Education
MUSIC:	Faculty of Music The Royal Conservatory of Music Year Book Syllabi (Please State Subject)
NURSING:	School of Nursing
PHARMACY:	Faculty of Pharmacy
PHYSICAL AND HEALTH EDUCATION:	School of Physical and Health Education
SOCIAL WORK:	School of Social Work

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*Write to: Ontario Institute for Studies in Education, 252 Bloor Street West, Toronto 181, Ontario.

NOTES

NOTES

NOTES

University
of Toronto

Faculty of
Applied Science
and Engineering

Calendar 1972-1973

University of Toronto Press
1972

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CALENDAR 1972

January

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CALENDAR 1973

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Calendar 1972-1973

FALL TERM, 1972

July 1	Saturday	Dominion Day. Buildings closed.
August 7	Monday	Civic Holiday. Buildings closed.
August 21	Monday	Students entering III Civil Engineering report at Survey Camp.
August 29	Tuesday	Meeting of Faculty Council.
August 30	Wednesday	*Registration of First Year students, from 9:30 a.m. to 4:30 p.m.
August 31	Thursday	*Registration of Second Year students, from 9:30 a.m. to 12:00 noon. *Registration of Third Year students, from 2:00 p.m. to 4:30 p.m.
September 1	Friday	*Registration of Fourth Year students, from 9:30 a.m. to 12:00 noon. *Students who reside outside Metropolitan Toronto may register on Tuesday, September 5, 1972, without penalty.
September 4	Monday	Labour Day. Buildings closed.
September 5	Tuesday	Orientation program for First Year students.
September 6	Wednesday	Lectures and laboratory work commence at 9:00 a.m.
September 22	Friday	Last date for students to add or substitute courses.
October 2	Monday	Meeting of Faculty Council.
October 9	Monday	Thanksgiving Day. Buildings closed.
October 20	Friday	Last date for students to drop a course without academic penalty.
November 1	Wednesday	Meeting of Faculty Council.
November 10	Friday	Last date for withdrawal from the Fall Term without academic penalty.
December 1	Friday	Meeting of Faculty Council.
December 6	Wednesday	Last day of lectures in Fall Term.

December 7	Thursday	
to		
December 20	Wednesday	Study and examinations in Fall Term courses.
December 25	Monday	Christmas Day. Buildings closed.

SPRING TERM, 1973

January 1	Monday	New Year's Day. Buildings closed.
January 8	Monday	Students of all years report at the Galbraith Building to confirm their enrollment for the Spring Term.
January 9	Tuesday	Lectures and laboratory work commence at 9:00 a.m.
	Monday	Meeting of Faculty Council.
January 19	Friday	Last date for students to add or substitute Spring Term courses.
February 5	Monday	Meeting of Faculty Council.
February 16	Friday	Last date for students to drop a Spring Term course without academic penalty.
March 1	Thursday	Meeting of Faculty Council.
March 9	Friday	Last date for withdrawal from the Spring Term without academic penalty.
April 3	Tuesday	Meeting of Faculty Council.
April 13	Friday	Last day of lectures in Spring Term.
April 16	Monday	
to		
April 30	Monday	Study and examinations in Spring Term courses.
May 2	Wednesday	Meeting of Faculty Council.

II

The Faculty of Applied Science and Engineering

ADMINISTRATIVE STAFF

Dean: J. M. Ham, B.A.SC., S.M., SC.D.(M.I.T.)
Associate Deans: P. E. Burke, B.E.(N. S. TECH.), M.A.SC.
G. B. Craig, M.A.SC., PH.D.
Executive Assistant and Secondary Schools Liaison Officer:
J. S. Hewitt, B.SC.(QU.), M.SC., PH.D.(BIRM.)
Assistant Dean and Secretary: J. A. Gow, B.A.SC.
Assistant Secretary: W. J. Dowkes, B.A.SC.

The Faculty of Applied Science and Engineering in the University of Toronto offers the widest range of undergraduate and postgraduate studies in engineering in Canada. The four year Bachelor of Applied Science (B.A.Sc.) undergraduate program is offered in Civil, Chemical, Electrical, Geological, Industrial and Mechanical Engineering, in Metallurgy and Materials Science and in Engineering Science. The Engineering Science program offers specific options in Aerospace, Chemical, Computer Science, Electrical, Geophysics, Materials Science, Nuclear and Thermal Power and Physics.

The Faculty offers, through the School of Graduate Studies, postgraduate programs for the Master of Applied Science (M.A.Sc.), the Master of Engineering (M.Eng.) and the Doctor of Philosophy (Ph.D.). Through the immense diversity of the resources of the University it is possible to do research in bio-engineering (engineering and medicine), in environmental engineering (urban planning and the control of pollution in air, water and land), in the history of technology, etc. This remarkable pattern of bridges linking the arts, sciences and professions in studies of man, his ideas and works adds a distinctive vitality and range to engineering at Toronto.

There are some 2200 undergraduate students and 600 postgraduate students. Undergraduates are taught not only by the staff of the Faculty but also by staff of University departments in Chemistry, Geology, Mathematics, Physics, English, History, Philosophy and Political Economy. On the staff of the Faculty alone there are some 180 professors.

From its historic beginnings in the School of Practical Science (S.P.S.) in the eighteen-seventies, the Faculty has grown since 1906 as an integral and senior part of the University. For students an important historical fact is that the Engineering Society, the student society of the Faculty, with its "Cannon" and "LGMB" band, is the oldest engineering organization of any formal kind in Canada.

The Faculty is located on the main campus in a rectangle bounded on the south by College Street, the west by St. George Street, the north by Convocation Hall and on the east by Taddle Creek Road where, in the days of Canadian Confederation there was indeed a creek so named.

The administrative offices are located in the southwest corner of the Galbraith Building at 35 St. George Street. Students and visitors may obtain information and assistance here.

SUMMARY OF STUDENTS IN ATTENDANCE — *Session 1971–1972*

COURSE		1	3	4	5	6	7	8	9	TOTAL
Year	I	112	110	54	172	82	106	15	27	678
	II	78	115	83	69	60	102	32	38	577
	III	70	75	60	71	57	96	16	14	459
	IV	70	95	73	63	81	112	14	16	524
TOTAL										2238
Special Students										7

III

General Information Admission and Registration

ADMISSION REQUIREMENTS

1. Full details of the University of Toronto undergraduate admission requirements for 1973 are contained in the Undergraduate Admission Handbook 1973–74 available on request from the Office of Admissions, University of Toronto, Toronto 181, and in all Ontario secondary schools. The 1972 requirements follow.

2. ONTARIO GRADE 13 GENERAL REQUIREMENTS:

Entrance to the First Year of the undergraduate courses is offered, depending upon the number of places available, to candidates from Ontario secondary schools who demonstrate good standing, based upon the following evidence:

1. Completion of secondary school studies, including a full program of academic work at the Grade 13 level.
2. A recommendation by the secondary school last attended regarding fitness for university studies.
3. A complete academic report for the three final years of secondary school.
4. Results of standardized tests offered by the Service for Admission to College and University.

The Grade 13 program should include Mathematics A, Mathematics B, Physics and Chemistry. Superior students who have completed a full Grade 13 but who lack one of the latter three courses will also be eligible.

Candidates seeking admission to the program in Engineering Science should have excellent standing.

3. APPLICATION PROCEDURES

Candidates currently in Ontario Grade 13 should apply through their high school using the General Application Form.

Other candidates should write to the Office of Admissions for a questionnaire which they will be invited to fill out for preliminary consideration.

4. STANDARDIZED TESTS

Candidates from Ontario secondary schools are encouraged to write the standardized tests offered by the Service for Admission to College and University. Candidates from educational jurisdictions outside Ontario may improve their competitive position by taking the aptitude and applicable achievement tests offered by the Service for Admission to College and University or the aptitude test offered by the College Entrance Examination Board. For information they should write to the Service for Admission to College and University, 151 Slater Street, Ottawa, Canada, or to the College Entrance Examination Board, Box 592, Princeton, New Jersey 08540, U.S.A.

5. CANDIDATES OFFERING CERTIFICATES OTHER THAN ONTARIO GRADE 13:

The following certificates are usually accepted as equivalent to Ontario Grade 13 although individual subjects cannot always be equated. Candidates offering Senior Matriculation programs from provinces other than Ontario must offer from their final secondary school year a full program including mathematics, physics and chemistry.

Alberta, Manitoba, Nova Scotia, Saskatchewan — Grade 12
British Columbia, New Brunswick — Grade 13 or First Year University
Newfoundland — First Year Memorial University
Prince Edward Island — First Year course at University of Prince Edward Island.
Quebec — Senior High School Leaving Certificate; English Catholic Senior High School Leaving Certificate (5th Year High—Grade 12). Other certificates as well as C.E.G.E.P. I will be considered.

UNITED STATES, CENTRAL AND SOUTH AMERICA

First Year University standing (normally 30 semester hours) in acceptable subjects from an accredited institution. Students with high school diploma and C.E.E.B. Advanced Placement examinations will be considered.

ENGLAND, WEST INDIES, EAST AND WEST AFRICA, HONG KONG

General Certificate of Education, Higher School Certificate or University of Hong Kong Matriculation Certificate showing either passes in five subjects of which at least two must be passed at advanced (or principal) level; or passes in four subjects of which at least three must be passed at advanced (or principal) level. In either case passes are required in Physics, Chemistry and an acceptable mathematics subject. At least two of these must be at advanced level.

INDIA, PAKISTAN

Bachelor's degree with high standing.

6. ENGLISH FACILITY

Applicants for the University of Toronto who are not Canadian citizens and whose mother tongue is not English may be required to meet an appropriate standard in a recognized test of English facility such as the University of Michigan English Language Test, the Certificate of Proficiency in English issued by the Universities of Cambridge or Michigan, or the Test of English as a Foreign Language (T.O.E.F.L.). The University of Toronto is a sponsoring agency for the University of Michigan English Language Test and information about the test is sent to any applicant of whom it will be required.

7. MATURE STUDENTS

Candidates 23 years of age or older who have lived in Ontario for a minimum period of one year may request special consideration if they have not completed the regular admission requirements in full. In order to be admitted to the Faculty of Applied Science and Engineering all such candidates must have Grade 13 or equivalent preparation in mathematics, physics and chemistry. Interested candidates should consult the Office of Admissions for further information.

8. APPLICATION PROCEDURES

Candidates currently in Ontario Grade 13 should apply through their high school using the General Application Form.

Other candidates should write to the Office of Admissions for a questionnaire which they will be invited to fill out for preliminary consideration.

The closing date for the receipt of applications is June 1. Only in circumstances which the Committee on Admissions deems exceptional will a late application be considered.

9. EARLY ADMISSION

(Ontario Grade 13 students only)

Ontario Grade 13 students with good school records may be offered admission as early as May 19.

Students wishing to be considered for Early Admission should ensure that their applications are forwarded by their schools not later than December 31.

10. CANDIDATES WHO HAVE PREVIOUSLY FAILED IN UNIVERSITY WORK

Candidates with a previous failure in university work may be considered individually on their merits; candidates with two previous failures are normally refused admission.

11. PROCEDURE FOR REGISTRATION

Detailed instructions concerning registration will be mailed to returning and newly admitted students before the beginning of each academic year.

12. HEALTH REQUIREMENTS

Every person admitted to the University as an undergraduate must, at the time of his or her first medical examination by the University Health Service, present satisfactory evidence of successful vaccination within three years prior to the date of the examination, or must be vaccinated by the examining physician.

COLLEGES

With the establishment of New College and Innis College, which are open to students of all faculties, it is now possible for students of the Faculty of Applied Science and Engineering to become members of a college. Membership in a college is not obligatory, and application for membership is at the option of the student.

Students entering the First Year who are interested in becoming members of either college should indicate their choice in the space provided on the University's admission application form. A college fee of $15 is required upon acceptance.

The facilities of Innis College and New College are described below.

INNIS COLLEGE

Innis College was constituted on July 1, 1964, and admitted its first students in the following September. It is a multi-faculty college of the University of Toronto, and includes undergraduate students in all Faculties and Schools of the University.

A special feature is the Writing Laboratory. This service offers assistance to Innis College students in the skills and methods of writing essays and other academic reports. A staff of experienced teachers is available to give individual instruction.

The College has limited residential space available in houses on campus. Separate application for residence accommodation must be made directly to the Residence Co-ordinator of Innis College.

Students entering First Year will be invited to apply for membership after they have been accepted into their Faculty or School. Students entering the Second to Fourth Years who wish to join the College should obtain an application form from the Registrar, Innis College, University of Toronto.

NEW COLLEGE

New College is a multi-faculty co-educational college; in addition to students from the Faculty of Arts and Science those from other Faculties and Schools are eligible for membership. This gives students from all divisions of the University the opportunity to participate in the activities of a college and to associate with students in other fields of study. Tutorial classes are provided for First Year students in some subjects.

The new building, centrally located on the west campus, provides academic, social and dining facilities for all members of the College and in addition accommodates nearly 300 male students and about 380 women students in residence.

Students applying for membership in the College who wish accommodation in the Residence must apply on the prescribed form which may be obtained from the Dean of Students, New College.

RESIDENCE ACCOMMODATION

DEVONSHIRE HOUSE

Devonshire House, the University Residence for Men, accepts students from all Faculties. The facilities of the residence include a library, music listening room, music practice room, common rooms, kitchenettes, laundry room, television and games rooms. It does not have a dining hall. Members may take their meals at Hart House, Howard Ferguson Hall, or New College, all located nearby.

Application forms may be obtained from the Secretary to the Dean, Devonshire House, University of Toronto. Application should be made as early as possible.

NEW COLLEGE

The residence facilities of New College, and the procedure for application, are described in the entry under Colleges, above.

OTHER COLLEGES

Each of the four Arts Colleges also maintains a residence into which some engineering students may be accepted. Further information may be obtained from the Dean of Women or the Dean of Men at University College, Victoria College, Trinity College or St. Michael's College.

HOUSING SERVICE

For the convenience of those students who are not able to find accommodation in the University and College residences, the University Housing Service maintains a listing of rooming houses, flats, apartments and homes. Information may be obtained by telephoning 928-2542.

Off-campus housing of this nature is not subject to University regulation. However every effort is taken to make the information on the accommodation as complete as possible and students are encouraged to assist in this effort by reporting on the quality of the accommodation that they have occupied.

CAMPUS CO-OPERATIVE RESIDENCE INCORPORATED offers residence and apartment accommodation for graduate and undergraduate students. Total occupancy is 300 in residence, half male, half female, and 50 in apartments. Meals are provided, and non-residents are invited to eat at the Co-op Dining Rooms. Since the University of Toronto has no official connection with Campus Co-operative Residence, Inc., inquiries should be addressed direct to Campus Co-operative Residence Incorporated, 395 Huron Street, Toronto 181, Ontario.

MARRIED STUDENT APARTMENTS

Apartment accommodation for married students is provided by the Ontario Student Housing Corporation in buildings located in the Bloor-Yonge area. The apartments (bachelor, one-bedroom and two-bedroom units) are unfurnished except for refrigerators, stoves and window drapes. Tenancy is by lease and is restricted to married couples of whom one or other must be registered as a full-time student at the University of Toronto. Additional information and application forms may be obtained at the University Housing Service, 49 St. George Street.

TARTU COLLEGE

Tartu College, opened in 1969, offers accommodation to undergraduate and post-graduate students in 444 single rooms and 15 double rooms. Cooking facilities are provided for groups of six. The rate for single rooms is $90 per month and $75 per month in double rooms. A rebate of $5 per month is granted to students who stay a full eight months. The college is located on Bloor Street at Madison Avenue. Since the University has no official connection with the college, all enquiries should be addressed to the Reservations Office, Tartu College, 310 Bloor Street West, telephone 925-4747.

ST. ANDREW'S-UNIVERSITY DAY NURSERY

This day nursery, established and supported by the University of Toronto, the Graduate Students' Union and the Students' Administrative Council, provides pre-school education and day care facilities for children of University of Toronto students. Children aged two to five years are accepted.

The nursery, located at St. Andrew's United Church, 117 Bloor Street East, is well equipped and staffed and is licensed under the Day Nursery Act, Province of Ontario. It operates from 8:30 a.m. to 5:45 p.m. throughout the winter and summer academic sessions. Fees are reasonable, and noon meals and morning and afternoon snacks are provided.

Priority of enrolment is given to children of University students, although children of other members of the University community will be considered.

Information may be obtained from the nursery (telephone 921-7078) or from the School of Graduate Studies.

THE UNIVERSITY OF TORONTO CAREER COUNSELLING AND PLACEMENT CENTRE

The Placement Centre, located at 581 Spadina Avenue, is open from 8:45 a.m., to 5 p.m., each week-day. The staff of the Centre maintain lists of part-time, permanent and summer employment opportunities in a wide variety of fields including the various branches of engineering. Engineering undergraduates are invited to drop in to discuss careers and employment problems.

Students looking for summer jobs should register at the Centre early in the academic term. This is important because job priorities are established on the basis of registration dates. Also, to be eligible for assistance under the Ontario Student Aid Plan, it is necessary for a student who has *not* obtained summer employment to have both registered at the Placement Centre and to have sought employment. The Centre will provide students who comply with these regulations with a letter for use with his O.S.A.P. application.

Early registration is also advisable for the fourth year permanent employment interviews which are organized by the Centre each year in the second week in December. Early registrants are given first choice of available interview times.

Students are given an opportunity to explore a variety of careers at a lecture and discussion series on "Careers in Industry, Government, and the Professions", presented by the Centre each year during the month of October. Watch the Varsity and Toike-Oike for specific career topics and dates.

IV

Fees, Deposits and Expenses

FEES

1. Undergraduate students in the Faculty of Applied Science and Engineering must pay annual fees according to the schedule listed below. The total fee in each case is made up of the academic fee and incidental fees; all incidental fees are payable in the first term.

Students will receive by mail in August a fees form and instructions for the payment of fees. In order to avoid delay in registration at the opening of the session it is recommended that at least the first term instalment of fees be forwarded by return mail before the end of August.

Fees may be paid by certified cheque, money order or personal cheque payable to the University of Toronto in Canadian funds, and mailed to the Office of the Comptroller, University of Toronto, Toronto 181.

2. Payment of at least the First Term instalment must be made before the opening day of the session. An admit-to-lectures card cannot be issued until the student has complied with this requirement.

3. The Second Term instalment of fees, if not already paid, is due on the opening day of the second term and must be paid not later than January 15. After this date a penalty will be imposed. All fees for the session must have been paid in full before the student can be admitted to the annual examinations.

4. Adjustment of fees for students who withdraw is made up to the twentieth week of the session.

5. Fees, residence dues and other charges set forth in this calendar are subject to change by the Board of Governors.

SCHEDULE OF FEES

Men Academic Year	*Academic Fee	†Incidental Fees	Total Fee (if paid in one instalment)	First Term Instalment	Second Term Instalment
I–IV	$650	$69	$719	$471	$260

Women					
I–IV	$650	$41	$691	$443	$260

*The Academic Fee includes the following fees:
Tuition; Library and Laboratory Supply; Annual Examinations; Laboratory Fee; and Degree.

†These Incidental Fees include the following fees:
For men – Hart House; Students' Administrative Council; Athletic; Health Service; Engineering Society; Faculty Athletic Association.
For women – Students' Administrative Council; Athletic; Health Service; Engineering Society.

LATE REGISTRATION FEE

Any student who registers after the last date for normal registration in his or her own faculty or school is required to pay a late registration fee as follows:

If registering within 7 calendar days – $10
If registering after 7 calendar days – $20

FEE FOR RE-CHECKING MARKS

A student who requests that his marks be re-checked must submit with his petition a fee of five dollars ($5) for each paper to be checked. The fee is refunded if an error is found.

FEE FOR TRANSCRIPTS

Transcripts of academic record are furnished by the Faculty Office on payment of a fee of one dollar ($1) per copy.

SPECIAL STUDENTS' FEES

The fee is $95 per subject, payable to the Fees Department.

SUMMARY OF STUDENTS' EXPENSES

The following approximate statement of expenses will give the student a general idea of the cost of obtaining an education in the Faculty of Applied Science and Engineering in the University of Toronto, exclusive of personal expenses:

1. Fees, see schedule page 16.
2. Board and lodging, per week .... $30 up
3. Books and instruments, per year .... about $150
4. Miscellaneous personal expenses .... $250 up

V

Programs and Degrees

UNDERGRADUATE PROGRAMS

The Faculty offers the following programs leading to the degree of Bachelor of Applied Science:

Civil Engineering (Program 1)
Mechanical Engineering (Program 3)
Industrial Engineering (Program 4)
Engineering Science (Program 5)
Chemical Engineering (Program 6)
Electrical Engineering (Program 7)
Metallurgy and Materials Science (Program 8)
Geological Engineering (Program 9)
Aerospace Engineering (offered as an option in Engineering Science. See page 76.)

Except for the First Year, which is also offered on a part-time basis through the Division of University Extension (see below), completion of any of these programs requires full-time attendance at the University. The curricula of the various programs are set out in detail in Section VI. The regulations for standing and promotion are given in Section VII.

FIRST YEAR – DIVISION OF UNIVERSITY EXTENSION

The First Year program (Division A only) is offered through the Division of University Extension for students interested in part-time evening study. Completion of this program qualifies the student for entry into the Second Year of all courses except Engineering Science. As there is no provision in the Division of University Extension for courses beyond the first-year level, students wishing to complete their studies for the degree must enter into full-time study in the regular courses in the Faculty of Applied Science and Engineering.

Information regarding the First Year Extension Program may be obtained from the Degree Courses Section, Division of University Extension, 84 Queen's Park, Toronto 181.

GRADUATE STUDY AND RESEARCH

Facilities are available in the Departments of the Faculty for postgraduate study and research leading to the degrees of Master of Engineering (M.Eng.), Master of Applied Science (M.A.Sc.), and Doctor of Philosophy (Ph.D.). For further information see the Calendar of the School of Graduate Studies.

SPECIAL STUDENTS

Graduates of the University of Toronto and of recognized universities who wish to take one or more undergraduate subjects may be registered as special students in the Faculty of Applied Science and Engineering, subject to the approval of the teaching department concerned. Application must be made to the Secretary of the Faculty.

INTERIM HIGH SCHOOL ASSISTANT'S CERTIFICATE TYPE A

Graduates of engineering programs may be admitted to Type A certificate courses at the College of Education, University of Toronto, if they submit official transcripts which indicate that they have sufficient academic credits.

Graduates of engineering programs who lack sufficient academic credits for admission to Type A courses at the College of Education may be eligible for admission to the Type B course and later for endorsement of the Type B certificate.

Inquiries regarding admission to the Type B course should be addressed to the Registrar, the College of Education, University of Toronto. Inquiries regarding endorsement of Type B certificates or admission to Type A certificate courses should be addressed to the Director, Committee on Advanced Standing, the College of Education, University of Toronto.

ASSOCIATIONS OF PROFESSIONAL ENGINEERS

Graduation from the Faculty of Applied Science and Engineering leads to registration as a Professional Engineer in the various Associations of Professional Engineers throughout Canada.

VI Curriculum

The curriculum is based upon a term system in which all courses of instruction (with the exception of certain courses taken in the Faculty of Arts and Science) will be one term in duration. There are two terms in the annual session, each concluding with final examinations in the courses offered. With the exception of the First Year, for which there are special provisions, students will be evaluated for promotion at the end of each term.

The curriculum provides a good deal of latitude to the student in choosing his program of study. A regular program consists of a maximum of six courses per term with a total weight of 48 units; with the approval of the Chairman of his Department a student enrolled in the second or higher years may elect to reduce his load to a minimum of 40 units per term, or to increase it to a maximum of 60 units. First-year students may not take less than the normal load of 48 units per term.

On the following pages of this section the curriculum of each program is set forth in detail. A common curriculum for students in First Year (in First and Second Years in Engineering Science) forms a basis in the fundamental subjects prior to subsequent specialization in various engineering disciplines. The student is able to choose from a wide range of technical electives in the senior years, and in the Fourth Year, all programs contain a thesis, which provides the student with the opportunity to carry out original work in his chosen field of study.

As a guide to students in apportioning their time a weight factor is shown opposite each course of instruction. The weight factor represents the number of hours per week, including both scheduled class-room time and home work, that the average student is expected to devote to that course. This weight factor is also used in the computation of the student's weighted average in the work of the term.

The program and regulations regarding the courses of study and examination, contained in this Calendar, hold good for this academic year only, and the Faculty of Applied Science and Engineering does not bind itself to adhere for the whole period of a student's course to the conditions here laid down.

ELECTIVE COURSES

Elective courses fall into four categories, viz. Technical Electives; Non-Technical Electives (in First and Second Year); Open Electives (in Third Year) and Free Electives (in Fourth Year). In general, the student should not select elective courses which would involve excessive duplication of material previously covered elsewhere in his program. The following paragraphs provide further instructions on the selection of elective courses:

1. TECHNICAL ELECTIVES: These are specified in the prescription for the program in which the student is registered. In most cases the choice is restricted to a specified list of available technical electives. The availability of a particular elective course may depend on a sufficient number of students wishing to take it; in a few courses it may be necessary to limit the number of students enrolled.

2. NON-TECHNICAL ELECTIVES (First and Second Years): Each student in the First and Second Year must include in his program a Non-Technical Elective in each term. In general, acceptable non-technical electives have as their central theme the study of man as an individual or of man as a social being.

The student may select his Non-Technical Elective from either of the following groups of courses:

(a) *"In-House" Non-Technical Electives*

The following courses have been arranged specifically for students of the Faculty of Applied Science and Engineering, and have been scheduled in slots MW1 and TR12, so as to be available to all students. (For descriptions of these courses, see page 155.)

ECO 281	Economics
ENG 281F/S	Effective Writing
ENG 282F/S	Twentieth Century Literature
ENG 283F/S	Canadian Literature
ENG 284F/S	Varieties of Fiction
ENG 285F/S	Drama and Modern Theatre
ENG 286F/S	Literature and Science
HPS 280F/S	History of Science and Technology
HPS 281F	History of Technology and Engineering up to the Industrial Revolution
HPS 282S	History of Technology and Engineering from the Industrial Revolution to the Present
HPS 283S	Technology, Engineering and Society
PHL 291F	Science and Society
PHL 292S	Science and Philosophy

(b) *Courses in the Faculty of Arts and Science*

Students desiring a broader choice in their non-technical electives may select courses from the following list of courses in the Faculty of Arts and Science (with the exceptions as noted). Students making this selection should bear in mind that some of these courses (viz. foreign languages) may be more demanding than the "in-House" courses.

Acceptable Arts and Science Courses (with exceptions as noted below). Courses listed in the calendar of the Faculty of Arts and Science under the following prefixes:

ANT
CIN
EAS
ECO
ENG
FAR
FRE
FSC
FSE
FSL
FSM
FSR
FST
FSW
FSY
GER
GLL
GRH
GRK
HIS
HPS
ISL
ITA
JAH
JAL
JAP
JAZ
JER
JMC
LAT
LIN
MUS
NES
PHI
PHL
POL
PRT
PSY
REL
SLA
SOC
SPA

Note: (i) Courses coded 195 may not be taken for credit
(ii) A half-course given over two terms has a code letter Y, e.g. ITA 221Y
(iii) Students wishing to take courses at the 300 level and higher must obtain the approval of the teaching department offering the course.

List of Exceptions (courses bearing the above prefixes which are not acceptable as Non-Technical Electives)

ECO 222	Computing for Social and Management Sciences
ECO 240F	Mathematical Approach to Macroeconomic Theory
ECO 241S	Mathematical Approach to Microeconomic Theory
ECO 343	Introduction to Mathematical Economics
MUS 343Y	Acoustics
PHL 250F	Modern Symbolic Logic
PHL 250S	Modern Symbolic Logic
PHL 251S	Probability and Inductive Logic
PHL 313F	Games, Decisions and Social Choice
PHL 350S	Intermediate Logic
PHL 353S	Set Theory
POL 206	Quantitative Methods for Political Science
PSY 209F	Physiological Psychology
PSY 315S	Introduction to Mathematical Psychology
PSY 319F	Physiology of Sensory Motor Behaviour
PSY 322	Physiological Psychology Laboratory
PSY 329S	Computer Applications to Psychology
SOC 201	Statistics and Research Methods
SOC 318	Advanced Research Methods

(c) *Other Courses*

The following courses are acceptable as non-technical electives:

LA 102 Land and Man

3. OPEN ELECTIVES (Third Year only): In each term of the Third Year there is provision for an "open elective" which the student must fill. Courses acceptable as open

electives are (i) any course which is acceptable as a Non-Technical Elective as defined in section 2 above, or (ii) any degree credit course listed in a University of Toronto Calendar, other than those offered by the Faculty of Applied Science and Engineering. In the latter case the student must obtain the approval of the teaching department offering the course.

4. FREE ELECTIVES (Fourth Year only): In each term of the Fourth Year there is provision for a "free elective" which the student must fill. Any degree credit course listed in a current University of Toronto Calendar is acceptable as a free elective. If taken within the Faculty, the free elective must be a course carrying a weight of at least 6 units per term.

BASIC SCIENCE COURSES

All programs in the Faculty (with the exception of Engineering Science) must contain at least one course designated as a basic science, which will normally be physics or chemistry offered by the Departments of Physics or Chemistry, respectively, in the Faculty of Arts and Science. Students who entered First Year in 1971–72 or later must take one such course in either the Second, Third or Fourth Years.

Some programs specify a basic science course as core material while others permit a choice*. The courses presently available are listed below. More information can be obtained from the curriculum prescription for the program in which the student is registered.

Program 3	– PHY 480F	Modern Physics (Commencing 1973–74)
Program 7	– PHY 384F	Thermodynamics and Statistical Mechanics
Programs 8, 9B	– PHY 282F	Introduction to Modern Physics
Program 9A	– PHY 283F	Basic Classical and Modern Physics
Programs 1, 4, 9C	Choose one of those courses listed above, or	
	PHY 284S	Basic Electromagnetism
	PHY 309F	Molecular Biophysics
	PHY 310S	Cellular Biophysics
	CHM 324F	Crystal Chemistry

There are also some full year courses available to students in the Third or Fourth Years of Programs 1, 4 and 9C which may be selected to fulfil the requirements for the basic science course and an open or free elective at the same time. Such courses are:

CHM 220	Chemical Statics and Dynamics
CHM 235	Structure and Synthesis in Chemistry
CHM 350Y	Instrumental Methods of Analysis
BCH 320	Introductory Biochemistry
BCH 321	Introductory Biochemistry
BIO 100	Principles of Biology

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*Basic science electives will be introduced in Program 6 commencing in 1973–74.

First Year Studies

Chairman For First Year Studies:

P. E. Burke, B.E. (N.S. TECH.), M.A.SC.

Coordinating Staff:

W. Janischewskyi, M.A.SC., Department of Electrical Engineering
W. A. Miller, PH.D.(MCG.), Department of Metallurgy and Materials Science
M. R. Piggott, M.SC., PH.D.(LOND.), Department of Chemical Engineering
R. A. Ross, M.A., PH.D. Department of Mathematics
S. Sandler, M.A.SC. Department of Chemical Engineering
G. D. Scott, M.A., PH.D., Department of Physics
S. D. Scott, B.SC., M.SC., PH.D. Department of Geology
I. W. Smith, M.A.SC. Department of Mechanical Engineering
G. T. Will, M.A.SC. Department of Civil Engineering
C. A. Wrenshall, B.E. (SASK.) Department of Civil Engineering

FIRST YEAR STUDIES

The First Year program is designed to build a strong foundation in the basic disciplines which underlie the whole field of engineering. There are two first year curricula – Division A, the standard curriculum and Division B, the enriched curriculum for students intending to pursue the Engineering Science program. Admission to the Division B curriculum is granted only to students with better-than-average ability in mathematics and the sciences. Students undertaking this curriculum must maintain satisfactory term and year averages in their first year work in order to pursue the Engineering Science program in their second year. (See page 42.)

Students entering Division A must elect one of the following programs in which they expect to continue in second year – Civil Engineering, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Electrical Engineering, Metallurgy & Materials Science, and Geological Engineering. Subject to the availability of places, a student who successfully completes the First Year in Division A may request to transfer to any other program within that Division.

Students wishing to transfer to a different program at the end of first year should make application to the Secretary of the Faculty not later than July 15.

FIRST YEAR CURRICULUM — DIVISION A

Civil Engineering	Electrical Engineering
Mechanical Engineering	Metallurgy and Materials Science
Industrial Engineering	Geological Engineering
Chemical Engineering	

Term 1F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Computer Programming†	APS 100F/S	1	—	3	7
Chemistry	CHE 100F	3	3	1	12
Applied Mechanics	CIV 100F	3	—	2	10
Engineering Graphics†	CIV 135F/S	2	5	—	8
Mathematics I	MAT 180F	4	—	3	12
Non-technical Elective*					8
Term 1S					
Computer Programming†	APS 100F/S	1	—	3	7
Engineering Graphics†	CIV 135F/S	2	5	—	8
Electricity and Magnetism	ELE 121S	3	1	1	10
Mathematics II	MAT 181S	3	—	4	13
Non-Technical Elective*					8
△ and one of:					
Engineering Design	APS 101S	2	1	1½	8
Chemical Engineering**	CHE 101S				8
Applied Physical Geology	GLG 180S	3	1½	—	8
Structure and Properties of Matter	MMS 100S	3	1½	—	8

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†One half of the students in Division A will take Computer Programming in Term 1F; the other half will take Engineering Graphics. The arrangement is reversed in Term 1S.

*Students will select one course each term from the list of Non-Technical Electives on page 21 of the Calendar, or from a list of courses available in the Faculty of Arts and Science.

△None of these technical electives shall be pre-requisite for any course given in a subsequent term.

**Students select three projects from a provided list, for which the contact times may vary from 3 hours of lectures to 7½ hours of laboratory weekly.

FIRST YEAR CURRICULUM — DIVISION B

Engineering Science

Term 1F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Mechanics (Statics)	CIV 101F	2	—	1	6
Chemistry	CHE 102F	3	3	1	10
Computer Programming	CSC 180F	1	3	—	5
Calculus I	MAT 194F	3	—	2	10
Elements of Physics I	PHY 180F	2	1½	1	9
Non-Technical Elective*					8
Term 1S					
Electricity	ELE 150S	3	—	—	8
Linear Algebra	MAT 185S	2	—	1	8
Calculus II	MAT 195S	2	—	1	7
Elements of Physics II	PHY 181S	2	1½	1	9
Non-Technical Elective*					8
△ **and one of:**					
Engineering Design	APS 101S	2	1	1½	8
Chemical Engineering**	CHE 101S				8
Engineering Graphics	CIV 136S	2	—	2½	8
Applied Physical Geology	GLG 180S	3	1½	—	8
Structure and Properties of Matter	MMS 100S	3	1½	—	8

*Students will select one course each term from the list of Non-Technical Electives on page 21 of the Calendar, or from a list of courses available in the Faculty of Arts and Science.

△None of these technical electives shall be pre-requisite for any course given in a subsequent term.

**Students select three projects from a provided list, for which the contact times may vary from 3 hours of lectures to 7½ hours of laboratory weekly.

Civil Engineering

Professor and Chairman of the Department:
T. C. Kenney, B.ENG.(MC.G.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.)

Associate Professors and Assistant Chairmen of the Department:
K. A. Selby, B.A.SC., M.B.A., PH.D.(ILL.)
P. M. Wright, B.E.(SASK.), M.SC., PH.D.(COL.)

Professors:
F. A. DeLory, B.ENG.(MC.G.), M.A.SC., D.I.C.(IMP.), PH.D.(LOND.)
C. Hershfield, B.SC., C.E.(MAN.), M.A.SC.
M. W. Huggins, B.A.SC., M.A.SC.
P. H. Jones, B.A.SC., M.S.(NORTHWEST.), PH.D.(NORTHWEST.)
R. H. Mills, B.SC.(WITWATERSRAND)
H. R. Rice, B.SC.(QU.)
J. Schwaighofer, DIP. ING.(GRAZ.), M.S.(PENN. ST.), PH.D.(PENN. ST.), DR. TECH.(GRAZ.)
R. M. Soberman, B.SC.(DALH.), PH.D.(M.I.T.)

Associate Professors:
J. D. Barber, B.A.SC., M.A.SC.
A. P. Bernhart, DIP. ING.(GRAZ.), DR.TECH.(GRAZ.)
M. P. Collins, B.E.(CANTERBURY), PH.D.(N.S.W.)
R. A. Collins, B.A.SC., M.S.(ILL.), PH.D.(ILL.)
A. C. Davidson, B.SC., C.E., B.SC., E.E.(MAN.), M.A.SC.
M. M. Davis, B.SC.(QU.), M.SC.(PURDUE)
H. R. Frizzle, B.SC., E.E.(N.S.TECH)
J. Ganczarzyk, M.SC., D.SC.(GLIWICE), D.SC.(WARSAW)
B. J. Haynes, B.A.SC.
G. W. Heinke, B.A.SC., M.A.SC., PH.D.(MCM.)
H. L. Macklin, B.A.SC.
V. R. Riley, B.A.SC., PH.D.(CANTERBURY)
E. I. Robinsky, B.A.(BEIRUT), B.SC.(BEIRUT), M.S.(HARVARD), PH.D.

G. N. Steuart, B.SC.(SASK.), M.SC.(CALIF.), PH.D.(CALIF.)
J. Timusk, B.A.SC., M.A.SC., PH.D.(LOND.)
S. M. Uzumeri, B.A.SC., M.A.SC.
J. Vlcek, B.SC.F.(N.B.), M.A.SC., D.SC(BRATISLAVA)
C. A. Wrenshall, B.E.(SASK.)

Assistant Professors:
R. C. Gunn, B.A.SC., M.A.SC., M.SC.(OHIO STATE)
E. Hauer, B.SC., M.SC.(TECHNION), PH.D.(CALIF.)
K. Meipoom, B.A.SC., M.A.SC.
G. K. Rodgers, B.A.SC., M.A.SC.(U.B.C.), PH.D.
G. T. Will, B.A.SC., M.A.SC.

Lecturers:
V. P. Borecky, DIP. ING.(PRAGUE), M.A.
E. Karuks, B.A.SC., M.A.SC.
R. G. Rice, B.A.SC., M.SC.(M.I.T.)

Special Lecturers:
A. C. R. Albery, B.A. (CANTAB.)
R. G. Foster, M.A.SC.
W. R. McDougall, B.A.SC.
J. C. McPherson, B.A.(CARLETON)
D. E. Thomson, B.A.SC., M.SC.(ILL.)

CIVIL ENGINEERING

Program 1

Civil Engineering as a profession is concerned with improving man's environment through the planning, designing and construction of facilities such as dams, buildings, transportation systems and municipal services. These activities encompass a very wide range of knowledge and this in turn creates special curriculum problems.

The program in Civil Engineering is arranged so that a student may undertake either a relatively broad study of the discipline or a more comprehensive examination of one of its principal fields (structural, municipal and sanitary, transportation, geotechnical, and surveying). This flexibility is derived from the fact that a fourth year student's program consists mainly of elective courses and a thesis. The departmental electives are timetabled so as to maximize the freedom of students to take the electives of their choice. Several project-oriented courses in the second year program provide students with an understanding of the engineering approach to planning and design.

In summary, the program is designed to develop well-informed creative engineers possessing innovative and directive capabilities.

SECOND YEAR CIVIL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Strength of Materials	CIV 210F	3	—	—	8
Surveying	CIV 255F	3	2	1	9
Computer Programming	CIV 260F	2	—	2	8
The Engineer and his Environment	CIV 267F	2	2	2	8
Calculus	MAT 280F	3	—	2	9
Non-technical Elective					8
Term 2S					
Engineering Materials	CIV 209S	4	2	1	10
Mechanics and Design of Structures	CIV 211S	4	—	2	10
Environmental Systems	CIV 240S	2	—	—	5
The Civil Engineer and his Profession	CIV 268S	2	2	2	8
Geology*	GLG 280S	2	1½	1	8
Non-technical Elective					8
Practical Experience	APS 299	—	—	—	—

*Students who have taken GLG 180S in First Year must replace GLG 280S by a Basic Science elective (see page 23). Students who have not taken GLG 180S must replace one technical elective in the Third or Fourth Years by a Basic Science elective.

THIRD YEAR CIVIL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Design of Structures II	CIV 312F	3	—	2	9
Soil Mechanics	CIV 321F	2	1	—	6
Survey Camp*	CIV 358F	—	—	—	—
Engineering Mathematics	CIV 370F	3	—	2	8
Probability and Statistics	CIV 371F	2	—	2	7
Fluid Mechanics	MEC 351F	3	3	—	10
Open Elective					8

THIRD YEAR CIVIL ENGINEERING (CONTINUED)

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Design of Structures III	CIV 313S	3	—	2	10
Foundations	CIV 322S	2	1	1	7
Transportation Systems	CIV 330S	3	—	2	8
Municipal Engineering	CIV 340S	2	—	2	7
Technical Elective**		3		2	8
Open Elective					8

*Survey Camp is taken prior to the commencement of regular courses in Third Year and the results included with those for the subsequent term on the basis of a weighting of 8 units.

**See list of Technical Electives on page 31.

FOURTH YEAR CIVIL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Administration and Management	CIV 475F	2	—	—	6
Technical Elective**		3		2	8
Technical Elective		3		2	8
Technical Elective		3		2	8
Technical Elective		3		2	8
Free Elective					8
Term 4S					
Public Speaking	CIV 474S	—	—	2	3
Thesis	CIV 499S	—	6	—	12
Technical Elective		3		2	8
Technical Elective		3		2	8
Technical Elective		3		2	8
Free Elective					8

***Technical Electives.* During Third and Fourth Year, students select eight technical electives. Each student is advised to consult with a member of the staff in establishing the electives in his program.

The technical electives offered by the Department of Civil Engineering are given below.

*Fall Term Electives***

CIV 405F	Advanced Strength of Materials
CIV 416F	Reinforced Concrete I
CIV 419F	Indeterminate Structures
CIV 421F	Foundations and Earthwork
CIV 429F	Air Photo Interpretation
CIV 430F	Traffic Engineering
CIV 431F	Transportation Planning
CIV 440F	Pollution Control Engineering
CIV 450F	Water Resources and Hydrology
CIV 455F	Photogrammetry and Remote Sensing
CIV 479F	Special Studies in Civil Engineering
CIV 498F	Thesis†

†With the permission of the Chairman of the Department, a student may elect to undertake a 21-unit thesis by taking both CIV 498F and CIV 499S.

Spring Term Electives

APS 420S	*Urban and Regional Planning
CIV 375S	*Engineering Economics and Decision Making
CIV 414S	*Advanced Engineering Materials
CIV 417S	Reinforced Concrete II
CIV 418S	Behaviour and Design of Steel Structures
CIV 420S	Construction Engineering
CIV 422S	*Engineering Geology
CIV 432S	Highway Engineering
CIV 456S	*Engineering Applications of Surveying
CIV 457S	Geodetic Control Surveys
CIV 479S	Special Studies in Civil Engineering
MEC 452S	Hydraulic Engineering

*Available to Third and Fourth Year students.

**With the approval of the Chairman of the Department a student may include, as part of his elective program, courses that are offered outside the Department provided that the University Department, Faculty or Institute offering the course has agreed to accept him for those courses.

Mechanical Engineering

STAFF OF THE DEPARTMENT

Professor and Chairman of the Department:
W. D. Baines, B.SC.(ALTA.), M.S., PH.D.(IOWA)

Associate Professor and Associate Chairman
D. S. Scott, B.SC.(QUEEN'S), M.SC.(QUEEN'S), PH.D.(NORTHWESTERN)

Professors:
F. C. Hooper, B.A.SC., D.I.C.(LOND.)
P. B. Hughes, B.SC.(MCGILL), D.ENG.(EMBRY-RIDDLE)
L. E. Jones, B.SC.(C.E.) (MAN.), M.A.SC., PH.D.
H. J. Leutheusser, DIP. ING.(KARLSRUHE), M.A.SC., PH.D.
F. P. J. Rimrott, DIP. ING.(KARLSRUHE), M.A.SC., PH.D.(PENN. STATE), DR. ING.(DARMSTADT)
I. W. Smith, M.A.SC.

Associate Professors:
A. H. Abdelmessih, B.M.E.(CAIRO), M.S.(OKLAHOMA STATE), PH.D.
A. B. Allan, M.A.SC.
I. G. Currie, B.SC.(STRATHCLYDE), M.A.SC.(B.C.), PH.D.(CAL.I.T.)
R. C. Fenton, DIP. ING.(BUD.), PH.D.(N.S.W.)
D. F. James, B.SC.(QUEEN'S), M.S.(CAL. TECH.), PH.D.(CAL. TECH.)
J. F. Keffer, M.A.SC., PH.D.
A. W. Neumann, B.A., DR.RER.NAT.(MAINZ)
B. Tabarrok, B.SC.(WOLVER. & STAFF.), D.PHIL.(OXON)
M. A. Townsend, B.S.(MICH.), M.S.(ILL.), PH.D.(WISCON.)
J. VandeVegte, DIP. ING.(DELFT), M.A.SC., PH.D.
C. A. Ward, B.SC.(TEX.), PH.D.(NORTHWEST.)

Assistant Professors:
D. L. Allen, B.SC.(DAL.), B.E.(N.S. TECH.), M.A.SC., PH.D.
R. C. Flanagan, B.SC.(N.B.), PH.D.(B.C.)

G. E. Godfrey, M.A.SC.
D. McCammond, B.SC.(QU. BELFAST), PH.D.(QU. BELFAST)
P. S. Shen, B.SC.(LOND.), M.SC.(BIRMINGHAM), PH.D.(LOND.)

Special Lecturer:
G. D. Ransford, B.A., B.C.E.(MELBOURNE), ING.D.(GRENOBLE)

MECHANICAL ENGINEERING

Program 3

Traditionally associated with the art and science of power generation and the machines and devices by which power is usefully applied and controlled, Mechanical Engineering, like other branches of the engineering profession, participates actively in the advancement of knowledge and interprets this knowledge in the design and development of practical systems.

In manufacturing industry, in the transportation and power utilities, in the high-performance field of air and space engineering, or in engineering aspects of major works and structures, the mechanical engineer finds professional occupation, either as employee or consultant. His responsibility will generally be for the superintendence of operations and personnel, for the design of products and processes, and may include the administration of enterprises.

The curriculum in Mechanical Engineering provides an analytical training in mathematics and the physical sciences designed as a disciplinary basis for active professional practice. Recognition is given, however, to the purer scientific and philosophical concepts essential to postgraduate study and research.

For the First Year curriculum see Division A, page 25.

SECOND YEAR MECHANICAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Engineering Law	APS 300F	1	—	—	2
Circuit Theory and Measurements	ELE 270F	3	1½	1½	10
Calculus	MAT 293F	2	—	2	8
Mechanics of Deformable Bodies I	MEC 211F	3	¾	2¼	10
Differential Equations	MEC 261F	3	—	3	10
Non-technical Elective					8
Term 2S					
Electromechanical Energy Conversion	ELE 272S	3	1½	1½	8
Dynamics I	MEC 201S	3	—	1½	8
Mechanics of Deformable Bodies II	MEC 212S	3	¼	1¼	8
Materials Science	MMS 223S	3	1½	—	8
Probability and Statistics	STA 282S	2	—	2	8
Non-technical Elective					8

THIRD YEAR MECHANICAL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thermodynamics	MEC 321F	3	3	—	10
Fluid Mechanics I	MEC 341F	3	2	1	10
Analysis and Design of Mechanisms	MEC 371F	3	—	3	10
Engineering Analysis I	MEC 362F	3	—	3	10
Open Elective					8
Term 3S					
Thermal Energy Conversion	MEC 322S	3	3	—	10
Vibrations	MEC 303S	3	¾	2¼	10
Engineering Analysis II	MEC 363S	3	—	3	10
Open Elective					8
and one of:					
Combustion Theory	MEC 323S	3	1½	—	10
Dynamics II	MEC 302S	3	—	1½	10
Elasticity	MEC 313S	3	—	1½	10
Fluid Mechanics II	MEC 342S	3	1½	—	10

FOURTH YEAR MECHANICAL ENGINEERING

Term 4F†		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Engineering Law	APS 300F	1	—	—	2
Numerical Analysis	CSC 481F	2	—	2	8
Control Systems	MEC 455F	3	1½	1½	10
Thesis	MEC 499	—	—	3	10
Free Elective					8
and one of:*					
Thermal Power Generation	MEC 424F	3	1½	—	10
Engineering Analysis III	MEC 464F	3	—	1½	10
Manufacturing Analysis	MEC 475F	3		1½	10
Thermal Environmental Design	MEC 420F	3	1½	—	10
Term 4S					
Heat and Mass Transfer	MEC 431S	3	1½	1½	9
Applied Fluid Mechanics	MEC 443S	3	3	—	9
Elasticity	MEC 495S	3	—	1½	9
Thesis	MEC 499	—	—	3	3
Free Elective					8

FOURTH YEAR MECHANICAL ENGINEERING (CONTINUED)

and one of:*		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Dynamics II	MEC 302S	3	—	1½	10
Fluid Mechanics II	MEC 342S	3	1½		10
Microscopic Thermodynamics	MEC 425S	3	1½	—	10
Computer-Aided Design	MEC 473S	3	—	1½	10

†A special elective, Project Design APS 401, is available to Fourth Year students. Beginning in 1973–74, another design course Engineering Design and Projects MEC 472F will be offered.

*With the approval of the Chairman of the Department, any other suitable course given by the Faculty of Applied Science and Engineering may be substituted as a Technical Elective.

Departmental electives for which there is insufficient demand may be withdrawn.

Industrial Engineering

STAFF OF THE DEPARTMENT

Professor and Chairman of the Department:
B. Bernholtz, M.A.,PH.D.(CAL. TECH.)

Associate Professor and Assistant Department Chairman:
R. W. P. Anderson, M.A.SC.

Professors:
J. W. Abrams, A.B.(CALIF.), PH.D.(CALIF.)
P. J. Foley, M.A.(GLASGOW)
A. Kruger, B.A., PH.D.(M.I.T.)
A. Porter, M.SC.(MANCH.), PH.D.(MANCH.), F.R.S.C.

Associate Professors:
J. Abrham, M.A.(CHARLES), PH.D.(CHARLES)
J. A. Buzacott, B.SC.(SYDNEY), B.E.(SYDNEY), M.SC.(BIRMINGHAM), PH.D.(BIRMINGHAM) (on leave for the Fall Term)
S. H. Cohn, M.A.
T. A. Lambe, B.A.SC.(U.B.C.), M.SC.(STAN.), PH.D.(STAN.)
J. G. C. Templeton, B.A., A.M.(PRINC.), PH.D.(PRINC.)

Assistant Professors:
A. A. Cunningham, M.A.(OXFORD), PH.D.(ADELAIDE)
M. J. M. Posner, B.A.SC., PH.D. (on leave for the session 1972–73)
I. B. Turksen, B.S.(PITTS.), M.S.(PITTS.), PH.D.(PITTS.)

Lecturer:
G. R. Comrie, B.A.SC.

Lecturer (part-time):
E. E. Pickett, B.A.SC., M.A.

Special Lecturers (part-time):
J. G. Heller, B.A.SC., M.A.SC., PH.D.
J. Vanderheyden, B.A.SC.
Mrs. J. L. Vitalis, B.A.(MINN.)

INDUSTRIAL ENGINEERING

Program 4

The modern view of Industrial Engineering is that of a field concerned with the analysis, design, improvement and operation of integrated systems of men, materials and equipment. This concept crystallized when it became clear that certain modern technical fields, including operational research, control theory, computer science, probability and statistics, systems theory and human factors engineering, constituted a body of knowledge particularly useful in the operation and management of modern business, industry and government.

As a logical outcome of this development, the course in Industrial Engineering was established in 1958 to provide graduates in engineering specializing in the theory and practice of these subjects. This specialization rests upon a substantial foundation in science and mathematics, in fundamental engineering disciplines including fluid mechanics, applied thermodynamics, electric science, mechanics of materials, materials science and automation, and in such subjects as economics, organizational structure, financial control and the behavioural sciences.

The curriculum in Industrial Engineering allows, but does not require, each student to take a Technical Elective outside the Department in each term in each of Second, Third and Fourth Year.

Students choosing to take technical electives are urged to select them with care, in order to improve their general engineering education or their knowledge of an area in which they wish to specialize. A list of areas of concentration and corresponding recommended subjects is distributed to students in Industrial Engineering to assist them in their choice of technical electives.

The staff and fourth year students of the Department conduct a seminar series in the fall term. Also, the staff and third year students conduct a seminar series in the spring term. Although attendance is not required and no academic credit is given, these seminars are considered an important part of each student's engineering education. Members of the staff and invited speakers prominent in the academic, governmental and business communities conduct a series of talks followed by general discussion.

For the First Year Curriculum see Division A, page 25.

SECOND YEAR INDUSTRIAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Elements of Industrial Engineering I	IND 200F	2	—	2	8
Computers and Programming I	IND 202F	2	—	2	8
Calculus	MAT 293F	2	—	2	8
Probability	STA 291F	2	—	2	8
Non-technical Elective					8
and one of:					
Materials Science	MMS 222F	3	3	—	8
Technical Elective*†					8
Term 2S					
Elements of Industrial Engineering II	IND 201S	2	—	2	8
Calculus and Differential Equations	MAT 294S	2	—	2	8
Statistics	STA 292S	2	—	2	8
Non-technical Elective					8
and two of:					
Mechanics of Materials	CIV 205S	2	3	—	8
Electrical Engineering	ELE 271S	3	1½	1	8
Technical Elective*†					8

*Technical Electives are courses which satisfy one or more of the following criteria:

1. A technical course listed in the current calendar of the Faculty of Applied Science and Engineering with a weight not less than 7 units. Exclusion: Core courses in the Industrial Engineering program.
2. A course listed in the Faculty of Arts and Science calendar in one of the following subject areas: Mathematics, Computer Science, Astronomy, Physics, Chemistry, Biological Sciences, Geology.
3. A course which relates to one of the Department's areas of concentration. The list of permitted courses is available from the Department.

In each case, the Department has the right to exclude certain courses which involve excessive duplication of material with courses listed in the Department's program. Students should note that their acceptance in a course given by another Department may require approval by the Department.

†Basic Science Course. Students who entered First Year in 1971–72 or later are required to take one basic science course in either Second, Third or Fourth Year. A list of permissible basic science courses is given on page 23. This requirement can be met by using one of the six possible technical electives.

THIRD YEAR INDUSTRIAL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Numerical Methods I	CSC 381F	2	—	2	8
Accounting I	COM 390F	2	—	1	8
Operational Research I	IND 301F	2	—	2	8
Computers and Programming II	IND 303F	2	—	2	8
Open Elective					8
and one of:					
Differential Equations	APM 391F	2	—	2	8
Industrial Relations	IND 304F	2	—	1	8
Technical Elective*					8
Term 3S					
Operational Research II	IND 302S	2	—	2	8
Control Engineering	MEC 357S	2	1	1	8
Probability and Statistics	STA 392S	2	—	2	8
Open Elective					8
and two of:					
Numerical Methods II	CSC 386S	2	—	2	8
Accounting II	COM 391S	2	—	1	8
Fluid Mechanics and Thermodynamics	MEC 348S	2	3	—	8
Technical Elective*					8

*See page 38 for note on Technical Electives.

FOURTH YEAR INDUSTRIAL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Free elective					8
and five of:					
State Space Methods in Process Control	IND 407F	2	—	1½	8
Man as an Individual	IND 411F	2	—	—	8
Fundamentals of Management Science	IND 413F	2	—	1½	8
Stochastic Models	IND 417F	2	—	1½	8
System Simulation	IND 418F	2	—	1½	8
Management Information Systems	IND 421F	2	—	1½	8
Human Factors in Man-Machine Systems	IND 422F	2	3	—	8
Term Thesis*	IND 497F	—	6	—	8
Year Thesis*	IND 499	—	6	—	8
Technical Elective					8
Term 4S					
Free Elective					8
and five of:					
Optimal Control of Processes	IND 408S	2	—	1½	8
Organizational Behaviour	IND 412S	2	—	—	8
Applications of Management Science	IND 414S	2	—	1½	8
Production Systems	IND 415S	2	—	1½	8
Advanced Industrial Engineering	IND 416S	2	—	1½	8
Information and Optimization	IND 419S	2	—	1½	8
Mathematical Programming	IND 420S	2	—	1½	8
Human Factors in Man-Machine Systems	IND 422S	2	3	—	8
Term Thesis*	IND 498S	—	6	—	8
Year Thesis*	IND 499	—	6	—	8
Technical Elective					8

*At least one of IND 497F, IND 498S and IND 499 must be selected. If IND 499 is selected, then neither IND 497F nor IND 498S may be selected.

Engineering Science

FACULTY MEMBERS OF THE DIVISION

Chairman of the Division:
B. P. Stoicheff, B.A.SC., M.A., PH.D. (Professor of Physics)

Associate Chairman of the Division:
I. H. Rowe, M.A.SC., D.I.C.(IMP. COLL.), PH.D.(LOND.), (Associate Professor of Electrical Engineering)

Members of the Division:
R. L. Armstrong, M.A., PH.D. (Associate Professor of Physics)
K. T. Aust, M.A.SC., PH.D. (Professor of Metallurgy and Materials Science)
G. F. D. Duff, M.A., PH.D., F.R.S.C. (Professor and Chairman of the Department of Mathematics)
J. N. P. Hume, M.A., PH.D. (Professor of Physics and Computer Science)
I. H. Spinner, M.A.SC., PH.D. (Professor of Chemical Engineering)
J. VandeVegte, DIP. ING.(DELFT), M.A.SC., PH.D. (Associate Professor of Mechanical Engineering)

ENGINEERING SCIENCE

Program 5

The Engineering Science program is designed for students whose primary interest is in the applications of science to modern technology, and who wish to prepare themselves for careers in research, development or teaching. The undergraduate course provides excellent preparation for post-graduate work in a wide range of specialities in Engineering, Science and Mathematics, and the majority of graduates from this course do proceed to graduate study. Students who graduate from the course and do not continue their studies are nevertheless well qualified to fill a variety of positions in industry, government and teaching.

The courses offered are of a high standard, so that only students with better-than-average ability in, and aptitude for, mathematics and science can expect to succeed in them. For this reason, admission is granted only to those who have achieved high standing in their previous academic work, and continuation in the program requires a minimum of 55% at the end of the first term and 66% at the end of the second (see page 159). Transfers into Division A can normally be made without difficulty up to the end of the second year. Thereafter, each case is considered on its merits.

The curricula for the first two years of the course are common for all students, with some technical electives available in terms 1S and 2S. There are available eight carefully planned *options*,† each of which provides a specialized preparation for a particular branch of applied science. In addition students have the opportunity not to enroll in any one of these options, but to take an *elective program*, as outlined below.

For the First Year curriculum see Division B, page 26.

SECOND YEAR ENGINEERING SCIENCE

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Numerical Methods	CSC 281F	2	—	1	7
Chemical Systems	CHE 209F	3	3	—	8½
Electric Circuits	ELE 250F	3	3	—	8½
Calculus III	MAT 295F	3	—	1	8
Physics III (Fields and Waves)	PHY 280F	3	1½	1	8
Non-technical Elective					8
Term 2S					
Complex Variables	MAT 289S	3	—	1	8
Physics IV (Quantum Physics)	PHY 281S	2	1½	1	8
Probability and Statistics	STA 287S	3	—	1	8
Non-technical Elective					8
two of:					
Engineering Design*	APS 201S	—	—	6	8
Mechanics of Materials	CIV 203S	2	—	3	8
Computer Languages	CSC 280S	2	—	—	8

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†For further information about the Aerospace Option, see page 76.

*This course will be limited to 20 students.

Students entering third year may elect

(a) to enrol in one of the 8 options listed, in which case up to two substitutions of courses may be permitted, or

(b) to select a program that does not conform to any one of the options.

In case (a), substitutions must be on a basis of roughly equal weights, so that the modified program has approximately the same weight as the standard option. In case (b), the weight shall average approximately 48 units per term. In both cases, the selection of courses is subject to the constraints imposed by the current timetable, and by prerequisites. Courses may be chosen from among those offered to other options in Engineering Science; from among those listed in the Calendar that are offered in programs other than Engineering Science; or, with the approval of the offering department, from among those offered in other Faculties.

All electives and substitutions require the approval of a member of the Division Staff.

THIRD YEAR ENGINEERING SCIENCE

Option 5A, Aerospace

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations I	APM 393F	3	—	—	8
Mechanics	AER 301F	3	—	1½	8
Mechanics of Structures	AER 302F	3	—	1½	8
Aerospace Laboratory I	AER 303F	—	3	—	8
Technical Elective					8
Open Elective					8

Term 3S					
Algebra	MAT 390S	3	—	—	8
Aerospace Laboratory II	AER 304S	—	3	—	7
Fluid Mechanics	AER 305S	3	—	1½	8
Control Systems	ELE 358S	3	1½	1	9
Technical Elective					8
Open Elective					8

Option 5C, Chemical

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Mass Transfer Operations I	CHE 312F	2	—	2	9
Thermodynamics and Kinetics I	CHE 303F	2	3	—	9
Chemical Engineering Problems and Lab I	CHE 315F	—	2	—	7
Technical Elective					8
Open Elective					8

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Algebra	MAT 390S	3	—	—	8
Thermodynamics and Kinetics II	CHE 304S	2	3	—	9
Mass Transfer Operations II	CHE 313S	2	—	1½	8
Chemical Engineering Problems and Lab II	CHE 316S	—	2	—	7
Molecular Engineering	CHE 317S	3	—	—	8
Open Elective					8

Option 5CS, Computer Science

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Physical Electronics I	ELE 350F	2	1½	—	7
Electronics I	ELE 351F	2	1½	—	8
Computer Organization	ELE 353F	3	1½	1	10
Switching Theory	ELE 359F	2	—	1	7
Open Elective					8

Term 3S					
Algebra	MAT 390S	3	—	—	8
Operational Research	IND 331S	2	—	2	7
Electronics II	ELE 360S	3	1½	—	8
System Software I	CSC 380S	2	6	—	10
Theory of Computation	CSC 390S	2	—	—	7
Open Elective					8

Option 5E, Electrical

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Physical Electronics I	ELE 350F	2	1½	—	7
Electronics I	ELE 351F	2	1½	—	8
System and Signal Analysis I	ELE 355F	3	—	1	8
Electromagnetic Fields	ELE 357F	3	1½	1	9
Open Elective					8

Term 3S					
Algebra	MAT 390S	3	—	—	8
Physical Electronics II	ELE 352S	2	1½	—	7
Electronics II	ELE 354S	3	3	—	10
System and Signal Analysis II	ELE 356S	3	1½	—	8
Open Elective					8

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
and one of:					
Quantum & Statistical Mechanics	PHY 382S	3	—	—	8
Digital Systems	ELE 314S	2	¾	—	6
Other Technical Elective					8
Option 5G, Geophysics					
Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Principles of Physical Geology	GLG 120F	2	3	—	9
Physics of the Earth	PHY 412	2	—	—	7
Electromagnetic Fields	ELE 357F	3	1½	1	9
Technical Elective*					8
Open Elective					8
Term 3S					
Algebra	MAT 390S	3	—	—	8
Principles of Historical Geology	GLG 122S	2	3	—	9
Physics of the Earth	PHY 412	2	—	—	7
Technical Elective*					8
Open Elective					8
and one of:					
Physics of Solids and Fluids	PHY 224S	2	—	—	8
Quantum & Statistical Mechanics	PHY 382S	3	—	—	8
Option 5M, Materials Science					
Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Physical Metallurgy	MMS 303F	3	3	—	8
Metallurgical Thermodynamics	MMS 306F	3	—	4	9
Technical Elective					8
Open Elective					8
and one of:					
Composite Materials	CHE 413F	2	—	1	7
Polymer Engineering	CHE 415F	2	—	1	7

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*At least one of these technical electives must be a course offered by a Department of the Faculty of Applied Science and Engineering or by the Department of Geology.

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Algebra	MAT 390S	3	—	—	8
Physics of Metals	MMS 304S	3	3	—	8
Materials Science	MMS 307S	3	—	—	8
Solid State Physics	PHY 304X	2	3	—	9
Technical Elective					8
Open Elective					8

Option 5NT, Nuclear & Thermal Power

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Fluid Mechanics	MEC 354F	3	3	—	12
Statistical Thermodynamics	MEC 326F	3	1½	1½	12
Heat Engineering	MEC 327F	2	3	—	8
Open Elective					8

Term 3S					
Algebra	MAT 390S	3	—	—	8
Quantum and Statistical Mechanics	PHY 382S	3	—	—	8
Control Systems	ELE 358S	3	1½	1	9
Experimental Stress Analysis	MEC 315S	2	1	1	8
Technical Elective					8
Open Elective					8

Option 5P, Physics

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Mechanics	AER 301F	3	—	—	8
Modern Physics Laboratory	PHY 327F	—	6	—	10
Open Elective					8
and one of:					
Physical Electronics I	ELE 350F	2	1½	—	7
Electronics I	ELE 351F	2	1½	—	8
Electromagnetic Fields	ELE 357F	3	1½	1	9
and one of:					
Geophysics	PHY 225F	2	—	1	8
Thermodynamics	PHY 303F	2	—	—	8
Nuclear and Particle Physics	PHY 305F	2	—	—	8
Molecular Biophysics	PHY 309F	2	—	—	8

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Algebra	MAT 390S	3	—	—	8
Quantum and Statistical Mechanics	PHY 382S	3	—	—	8
Open Elective					8
and one of:					
Physical Electronics II	ELE 352S	2	1½	—	7
Experimental Stress Analysis	MEC 315S	2	1	1	8
Control Systems	ELE 358S	3	1½	1	9
and two of:					
Physics of Solids & Fluids	PHY 224S	2	—	—	8
Solid State Physics	PHY 304S	2	—	—	8
Applied Nuclear Physics	PHY 307S	2	1	—	8
Cellular Biophysics	PHY 310S	2	—	—	8

FOURTH YEAR ENGINEERING SCIENCE

Option 5A, Aerospace

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thesis	APS 495	—	—	—	8
Differential Equations II	APM 441	3	—	—	8
Open Elective					8
*and a selection of courses from Groups A and B totalling approximately 24 units:					
Group A					
Aerodynamics	AER 401F	3	—	1½	9
Space Flight Dynamics	AER 402F	2	—	1½	8
Advanced Mechanics of Structures	AER 403F	2	—	1½	8
Group B					
Physics and Mechanics of Solids	AER 404F	3	—	1½	9
Plasmadynamics	AER 405F	3	—	1½	9
Engineering Design I	AER 406F	—	3	—	8
Aerospace Laboratory III	AER 408F	—	6	—	8

*In the aggregate of terms 4F and 4S the student's program must include at least two courses from Group A. Courses in Groups A and B for which there is insufficient demand may be withdrawn.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Term 4S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thesis	APS 495	—	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8
Open Elective					8
*and a selection of courses from Groups A and B totalling approximately 24 units:					
Group A					
Gasdynamics	AER 410S	3	—	1½	9
Stability and Control of Aircraft	AER 411S	2	—	1½	8
Aerolasticity	AER 412S	2	—	1½	8
Group B					
Physics of Radiating Gases	AER 413S	3	—	—	9
Acoustic Theory and Noise Control	AER 414S	2	1½	—	8
Control Systems	ELE 358S	3	1½	1	9
Engineering Design II	AER 407S	—	3	—	7
Aerospace Laboratory IV	AER 409S	—	6	—	7

Option 5C, Chemical

Term 4F					
Thesis	APS 496	—	—	—	5
Differential Equations II	APM 441F	3	—	—	8
Rate Processes I	CHE 435F	3	—	—	9
Free Elective					8
and two of:					
Chemical Plant Design	CHE 406F	—	—	6	9
Strategy of Product and Process Development	CHE 409F	2	3	—	9
Chemical Engineering Project	CHE 441F	—	6	—	9
Optimal Control of Chemical Systems**	CHE 437F	3	—	1½	9
Term 4S					
Thesis	APS 496	—	—	—	5
Applied Functional Analysis	APM 446S	3	—	—	8
Rate Processes II	CHE 436S	3	—	—	9
Free Elective					8

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*In the aggregate of terms 4F and 4S the student's program must include at least two courses from Group A. Courses in Groups A and B for which there is insufficient demand may be withdrawn.

**Not offered in 1972–73.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	Lab.	Tut.	Wt.
and two of:					
Molecular Thermodynamics	CHE 404S	2	—	1	8
Selected Topics in Organic Chemistry	CHE 439S	3	—	—	9
Modelling and Simulation of Chemical Systems	CHE 440S	3	—	—	9
Option 5CS, Computer Science					
Term 4F					
Differential Equations II	APM 441F	3	—	—	8
System Software II	CSC 480F	2	6	—	10
System & Signal Analysis I	ELE 355F	3	—	1	8
Communication Principles I	ELE 453F	2	—	1	7
Operating Systems	CSC 468F	2	—	1	8
Free Elective					8
Term 4S					
Thesis	APS 497S	—	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8
Computation Methods for Partial Differential Equations	CSC 446S	2	—	1	8
Techniques of Optimization	ELE 455S	3	—	1	8
Switching Circuits	ELE 432S	2	3	—	8
Free Elective					8
Option 5E, Electrical					
Term 4F					
Differential Equations II	APM 441F	3	—	—	8
Free Elective					8
Select courses from the following to total approximately 48 units for the term:*					
Computer Organization	ELE 353F	3	1½	1	10
Switching Theory	ELE 359F	2	—	1	7
Network Theory	ELE 412F	3	—	2	8
Semiconductor Physics	ELE 435F	2	1½	1	8
Computer Programming & Data Structure	ELE 440F	2	—	2	8
Techniques of System Theory	ELE 450F	2	1½	—	8
Electronics III	ELE 452F	2	3	—	8
Communication Principles I	ELE 453F	2	—	1	8
Thesis[1]	APS 495	—	—	—	8
Other Technical Elective					8

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*Courses for which there is insufficient demand may be withdrawn.

[1] Select either APS 495 or APS 498S, but not both.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Term 4S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Applied Functional Analysis	APM 446S	3	—	—	8
Free Elective					8
Thesis[1]	APS 495	—	—	—	8
Thesis[1]	APS 498S	—	—	—	8
Select courses from the following to total approximately 48 units for the term:*					
Introduction to Nuclear Engineering	CHE 430S	2	1½	—	8
Switching Circuits	ELE 432S	2	3	—	8
Quantum Electronics	ELE 437S	2	1½	1	8
Computer Organization	ELE 441S	2	3	—	8
Biomedical Engineering[2]	ELE 445S	3	1½	—	8
Communication Principles II	ELE 454S	2	3	—	8
Microwave Electronics	ELE 457S	2	1½	1	8
Power Semiconductor Circuits	ELE 433S	2	3	—	8
Operations Research	IND 331S	2	—	2	8
Integrated Circuits	ELE 431S	2	3	—	8
Techniques of Optimization	ELE 455S	3	—	1	8
Other Technical Elective					8

Option 5G, Geophysics

Term 4F					
Differential Equations II	APM 441F	3	—	—	8
Geophysical Methods	PHY 413X	2	6	—	12
Physics of the Earth	PHY 412	2	—	—	7
Thesis	APS 499	—	—	—	6
Technical Elective*					8
Free Elective					8
Term 4S					
Applied Functional Analysis	APM 446S	3	—	—	8
Geophysical Methods	PHY 413X	2	6	—	12
Physics of the Earth	PHY 412	2	—	—	6

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*Courses for which there is insufficient demand may be withdrawn.

[1] Select either APS 495 or APS 498S, but not both.

[2] Limited enrolment.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
Thesis	APS 499	—	—	—	6
Technical Elective*					8
Free Elective					8
Option 5M, Materials Science					
Term 4F					
Thesis	APS 495	—	—	—	8
Differential Equations II	APM 441F	3	—	—	8
Solid State Science	MMS 402F	3	3	1	9
Theory of Metallurgical Reactions	MMS 410F	2	—	2	8
Technical Elective					8
Free Elective					8
Term 4S					
Thesis	APS 495	—	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8
Advanced Materials Science	MMS 411S	3	3	—	8
High Temperature Physical Chemistry	MMS 409S	2	—	2	8
Technical Elective					8
Free Elective					8
Option 5NT, Nuclear & Thermal Power					
Term 4F					
Differential Equations II	APM 441F	3	—	—	8
Thermal Energy Conversion I	MEC 428F	3	3	—	11
Nuclear Engineering	CHE 442F	3	3	—	11
Thesis	APS 478	—	—	—	10
Free Elective					8
Term 4S					
Applied Functional Analysis	APM 446S	3	—	—	8
Thermal Energy Conversion II	MEC 429S	3	3	—	11
Heat Transfer	MEC 433S	2	—	—	6
Control Systems	ELE 358S	3	1½	1	9
Thesis	APS 478	—	—	—	6
Free Elective					8

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*These technical electives must all be courses offered by a department of the Faculty of Applied Science and Engineering or by the Department of Geology.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Option 5P, Physics

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations II	APM 441F	3	—	—	8
Technical Elective*					8
Free Elective					8
and three of:					
Quantum Theory I	PHY 400C	2	—	—	8
Statistical Mechanics I	PHY 401C	2	—	—	8
Nuclear Physics I	PHY 403C	2	—	—	8
Solid State Physics I	PHY 405C	2	—	—	8
Interaction of Radiation with Matter	PHY 406F	2	—	—	8
Group Theory & Molecular Physics	PHY 408F	2	—	—	8
Relativity Theory I	PHY 410C	2	—	—	8
Quantum Physics Laboratory I	PHY 427F	—	6	—	8
Term 4S					
Thesis	APS 498S	—	—	—	8
Technical Elective 1*					8
Technical Elective 2*					8
and choose 3 courses from the following, at least 1 from Group A:					
Group A					
Quantum Theory II	PHY 400D	2	—	—	8
Statistical Mechanics II	PHY 401D	2	—	—	8
Relativity Theory II	PHY 410D	2	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8
Group B					
Nuclear Physics II	PHY 403D	2	—	—	8
High Energy Physics	PHY 404S	2	—	—	8
Solid State Physics II	PHY 405D	2	—	—	8
Magnetic Resonance	PHY 407S	2	—	—	8
Quantum Optics	PHY 409S	2	—	—	8
Quantum Physics Laboratory II	PHY 428S	—	6	—	8

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*These technical electives must all be courses offered by a department of the Faculty of Applied Science and Engineering.

Chemical Engineering and Applied Chemistry

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CHEMICAL ENGINEERING

Program 6

Undergraduate study in the Department of Chemical Engineering and Applied Chemistry is an excellent preparation for not only a career as a professional chemical engineer, but also for many careers in applied science. In recent years, a large proportion of the graduates from the Department have pursued such careers in addition to those entering the major chemical and petroleum industries.

The professional chemical engineer is concerned with the development and operation of processes by means of which matter is chemically altered to a more useful form, and in the design, construction, operation and management of plant in which to effect such changes. In addition to such obviously chemical processes as those encountered in the petroleum refining and petro-chemical industry, a great variety of industrial processes involve chemistry and require the abilities of the chemical engineer. In order to equip a student to start his professional career as a chemical engineer, the undergraduate course is intended to provide him with training in the principles of the major divisions of chemistry and chemical engineering, together with the essentials of other engineering subjects.

Programs in applied science are available in the Department which are based on the core chemical engineering curriculum but which have emphasis, for example, in the following areas: environmental chemistry and engineering, polymer science, wood chemistry, materials science, ceramics, medical engineering, analytical chemistry, fluid mechanics, nuclear power engineering, nuclear chemistry, biochemical engineering, optimal control, surface chemistry, combustion, pipeline transportation, separation processes and heat transfer.

A particular emphasis can be achieved by selecting elective courses and a suitable project for the thesis. Many such courses are given by the Department, and, in addition, in certain areas, specialist courses in other Departments or Faculties may be selected e.g. courses in Biochemistry and Microbiology for a program with a biochemical engineering emphasis. In this way, maximum advantage may be taken of the resources within the whole University, and an individual student may arrange his program to suit his desires and career objectives. Exceptional flexibility exists in this approach since both a broad education in the applied and basic sciences and a focus towards a particular application may be enjoyed.

In the final year, the topic chosen for the thesis allows the student additional specialization. The thesis serves as an introduction to research, and its nature may vary widely depending on the interests of the staff and students. It may, for example, be concerned with an experimental laboratory investigation, the design of a process, or a computer study of a chemical system.

For the First Year curriculum see Division A, page 25.

SECOND YEAR CHEMICAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Physical Chemistry I	CHE 201F	2	—	—	5
Analytical Chemistry Laboratory*	CHE 203F				
Analytical Chemistry	CHE 204F	2	10½	—	14
Industrial Process Operations I	CHE 205F	3	—	2	9
Inorganic Chemistry I	CHE 217F	2	—	—	5
Calculus	MAT 280F	3	—	2	9
Non-technical Elective					8
Term 2S					
Physical Chemistry II	CHE 202S	2	3	—	8
Industrial Process Operations II	CHE 206S	3	6	2	13
Organic Chemistry	CHE 207S	3	3	—	10
Applied Math in Chemical Engineering	CHE 208S	2	—	1	6
Inorganic Chemistry II	CHE 218S	2	—	—	5
Non-technical Elective					8
Practical Experience	APS 299				

*A voluntary pre-session course offered by the Senior Staff in Chemical Engineering prior to the commencement of regular courses in Second Year.

THIRD YEAR CHEMICAL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thermodynamics and Kinetics I	CHE 301F	3	6	2	14
Applied Mathematics in Chemical Engineering	CHE 305F	2	—	1	6
Organic Chemistry II	CHE 309F	3	9	—	14
Mass Transfer Operations I	CHE 310F	2	—	2	8
Open Elective					8
Term 3S					
Thermodynamics and Kinetics II	CHE 302S	3	6	2	14
Mass Transfer Operations II	CHE 311S	2	4½	1	11
Fluid Mechanics	CHE 314S	3	1½	1	10
Open Elective					8
and one of:					
Fundamental Process Modelling and Simulation	CHE 306S	2	—	1	6
Organic Chemistry of High Polymers	CHE 307S	2	—	1	6
Chemical Engineering Economics	CHE 308S	2	—	1	6

FOURTH YEAR CHEMICAL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thesis and Public Dissertation	CHE 499	—	10	—	10
Free Elective					8
one of:					
Chemical Engineering Thermodynamics	CHE 402F	2	—	1	7
Interface Kinetics	CHE 403F	2	—	1	7
Chemical Reactors	CHE 432F	2	—	1	7
one of:					
Chemical Plant Design	CHE 405F	—	—	6	7
Process Modelling and Simulation	CHE 407F	2	—	3	7
Strategy of Product and Process Development	CHE 408F	2	3	—	7
one of:					
Advanced Separation Processes	CHE 410F	2	—	1½	7
Convective Heat & Momentum Transfer	CHE 411F	2	—	1½	7
Pipeline Transportation	CHE 412F	2	—	1½	7

FOURTH YEAR CHEMICAL ENGINEERING (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
one of:					
Composite Materials	CHE 413F	2	—	1	7
Polymer Engineering	CHE 415F	2	—	1	7
Pulp and Paper Chemistry, Technology and Engineering	CHE 417F	2	—	1	7
Term 4S					
Thesis and Public Dissertation	CHE 499	—	18	2	22
Free Elective					8
two of:					
Applied Nuclear Chemistry	CHE 418S	2	—	1	8
Ceramics	CHE 420S	2	—	1	8
Co-ordination Chemistry	CHE 422S	2	—	1	8
Environmental Engineering	CHE 423S	2	—	1	8
Instrumentation Methods	CHE 425S	2	—	1	8
Chemical Bonding	CHE 426S	2	—	1	8
Introduction to Nuclear Engineering	CHE 427S	2	—	1	8
Optimal Control*	CHE 431S	2	—	1	8
Molecular Thermodynamics	CHE 404S	2	—	1	8
Interfacial Phenomena and Disperse Systems	CHE 433S	2	—	1	8
Chemistry of Organic Compounds	CHE 434S	2	—	1	8

*Not offered in 1972–73.

Electrical Engineering

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ELECTRICAL ENGINEERING

Program 7

Electrical Engineers are concerned with all things electrical; but such a simple statement fails to convey any real notion of the great variety of activity in which they are engaged, the many aspects of their concern, or the nature of the education that they require.

Electrical engineers are, of course, still involved in the application of new knowledge to the basic areas — the generation, transmission and utilization of electrical power and the communication of information — but they are being faced daily with situations not envisaged even a few years ago. They are searching continuously for new approaches that may be better suited to future needs, as for example, magnetohydrodynamic generation, microelectronics and satellite communication. There is a growing demand for sophisticated electrical sensing and control equipment for a wide variety of non-electrical processes, and for electronic computers capable of the rapid processing of large volumes of information and the solving of increasingly complex problems.

Within any of these areas the electrical engineer may be engaged in research, development, design, manufacture, operation or management. He may have to assist other engineers and scientists in widely differing fields by supplying them with techniques or insights unfamiliar to them, as for example, in the developing field of bio-medical engineering, or he may have to coordinate the application of many technologies in a single project. In addition to all of this, he must accept considerable responsibility in community affairs.

It is obvious then, from the wide range of his possible involvement, that the electrical engineer needs a professional education of great breadth and depth. In the undergraduate course, stress is laid on building a solid foundation. The time limitation requires that only material which is essential can be included; much that might be immediately helpful must be omitted to make room for that which will still be relevant for several years. On this base, the graduate will have to build his continuing education.

The electrical engineer makes extensive use of mathematical techniques and concepts; mathematics is thus of the utmost importance and a large portion of the course is devoted to it. Fundamental subjects such as mechanics, electrical physics, chemistry and thermodynamics get considerable attention in the early years. The basic electrical engineering subjects (electromagnetic field theory, electronics, machine principles and circuit theory) follow these, with expansion and specialization in the final year. In the final year, students freely select their whole program from a wide range of elective subjects.

Electrical engineering is characterized by the relatively large proportion of its graduates who proceed to post-graduate study to get advanced training in a particular area. Information on this may be obtained from the calendar and other publications of the School of Graduate Studies.

For the First Year curriculum see Division A, page 25.

SECOND YEAR ELECTRICAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations	MAT 290F	3	—	2	8
Complex Variables & Vector Calculus	ELE 200F	3	—	2	8
Circuit Theory I	ELE 210F	3	1½	1	9
Materials Science I	MMS 221F	3	1½	—	8
Dynamics	MEC 205F	2	—	1	7
Non-Technical Elective					8
Term 2S					
Numerical and Probabilistic Methods	ELE 201S	3	—	2	8
Electric and Magnetic Fields	ELE 221S	3	—	2	8
Circuit Theory II	ELE 211S	3	1½	1	9
Materials Science II	MMS 227S	2	1½	—	7
Electronics I	ELE 231S	2	1½	1	8
Non-Technical Elective					8

THIRD YEAR ELECTRICAL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Applied Math I	ELE 300F	2	—	1	6
Electromechanical Systems I	ELE 312F	2	1½	1	8
System and Signal Analysis I	ELE 310F	3	—	1	7
Physical Electronics A	ELE 335F	2	1½	—	6
Fields and Waves	ELE 320F	2	1½	1	8
Thermodynamics and Statistical Mechanics	PHY 384F	3	—	1	7
Open Elective					8
Term 3S					
Digital Systems	ELE 314S	2	¾	—	6
Electromechanical Systems II	ELE 313S	3	1½	1	9
System and Signal Analysis II	ELE 311S	3	1½	1	9
Physical Electronics B	ELE 336S	2	—	1½	6
Electronics II	ELE 331S	3	3	—	10
Open Elective					8

FOURTH YEAR ELECTRICAL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Free Elective					8
Select additional courses from the following to total 48 units for the term:[2]					
Thesis[4]	ELE 498F	—	—	—	8
Thesis[4]	ELE 496F	—	—	—	16
Partial Differential Equations and Variational Calculus[5]	ELE 400F	2	—	2	8
Switching Theory	ELE 405F	2	—	2	8
Control Systems I	ELE 410F	2	1½	1	8
* Network Theory	ELE 412F	3	—	2	8
Illumination[6]	ELE 447F	3	1½	—	8
* Power System Analysis	ELE 413F	2	1½	1	8
Quantum Physics	ELE 436F	3	—	1	8
Electromagnetic Theory	ELE 420F	2	—	2	8
Electronics III	ELE 430F	2	3	—	8
Semiconductor Physics	ELE 435F	2	1½	1	8
Computer Programming & Data Structures	ELE 440F	2	—	2	8
Other Technical Elective[1,3]		—	—	—	8
Term 4S					
Free Elective					8
Select additional courses from the following to total 48 units for the term:[2]					
Thesis[4]	ELE 499S	—	—	—	8
Thesis[4]	ELE 497S	—	—	—	16
* Control Systems II	ELE 411S	2	1½	1	8
Radiation and Propagation	ELE 421S	2	1½	1	8
Communication Systems	ELE 416S	2	3	—	8
Switching Circuits	ELE 432S	2	3	—	8
* Computer Organization	ELE 441S	2	3	—	8
Power Semiconductor Circuits	ELE 433S	2	3	—	8
* Introduction to Nuclear Engineering	CHE 429S	2	1½	1	8
Microwave Electronics	ELE 457S	2	1½	1	8
* Biomedical Engineering[6]	ELE 445S	3	1½	—	8
Acoustic Theory and Noise Control[6]	AER 414S	2	1½	—	8
* Power System Control	ELE 414S	2	1½	1	8
Integrated Circuits	ELE 431S	2	3	—	8
* Electromechanical Systems III	ELE 419S	2	1½	1	8
Quantum Electronics	ELE 437S	2	1½	1	8
Other Technical Elective[1,3]		—	—	—	8

Footnotes to previous page:

*Bracketed courses can not be taken together because of timetable conflicts.

[1] Hours shown as guide only.

[2] For students proceeding at a normal rate; see page 159 for minimum and maximum loadings.

[3] Any third or fourth year engineering courses are acceptable. Other technical or physical science courses require the approval of the teaching department offering the course and the Department of Electrical Engineering.

[4] A thesis is compulsory. The minimum weighting is 8 for the year. The maximum permitted is 16 for the year. Thus the selections allowed are any one of ELE 496F, 497S, 498F or 499S; or both of ELE 498F and ELE 499S. The selection must be approved by the student's thesis supervisor.

[5] Not offered in 1972–73. Interested students may consult the Electrical Engineering Department concerning courses available from the Mathematics Department.

[6] Limited enrolment.

Metallurgy and Materials Science

STAFF OF THE DEPARTMENT

Professor and Chairman of the Department:
C. B. Alcock, B.SC., PH.D., A.R.C.S., D.SC.(LOND), F.R.I.C., M.I.M.M.

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Assistant Professors:
G. C. Weatherly, PH.D.(CANTAB)

METALLURGY AND MATERIALS SCIENCE

Program 8

In terms of its diversity and scale of operation, the metallurgical industry in Canada ranks among the world's outstanding industrial achievements; it is also responsible for a considerable portion of the country's economy. Thus, in this field of endeavour, the metallurgist fulfils an important and useful role in the extraction, fabrication and application of metals and their alloys.

In recent years the needs of modern society have made increasingly severe demands upon materials required for various types of construction. This had led to the development of the new field of materials science which applies many of the techniques of the metallurgist and others to the study of the relationship between the structure and properties of a wide spectrum of materials. For example, aerospace travel requires materials capable of withstanding extremes of heat, cold and pressure; the practical application of nuclear energy is limited only by the availability and costs of materials which can withstand in-pile operation; advances in communications depend upon the development of materials having special electrical and magnetic properties.

The program is perhaps unique in the Faculty in that it draws heavily on both physics and chemistry. It should, therefore, appeal to students with an interest in either of these basic scientific fields. The program is designed to place primary emphasis upon the fundamental principles of chemical metallurgy, physical metallurgy and materials science. In the Fourth Year, each student prepares a thesis on an experimental problem which, where possible, is related to research in progress within the Department. A wide range of electives in the Third and Fourth Years culminates in a final Term 4S which consists entirely of material chosen by the student in consultation with an assigned staff tutor. In this manner, the student may elect courses which emphasize either the industrial or the research aspects of metallurgy and materials science.

The Department is equipped with modern facilities for the study of the structure and properties of materials. This equipment includes x-ray diffraction units, an electron beam microprobe analyzer, electron microscopes, several optical metallographs, and materials preparation and testing equipment. Facilities for mineral processing and for the production and measurement of high temperatures and high vacuum are also available.

For the First Year curriculum see Division A, page 25.

SECOND YEAR METALLURGY AND MATERIALS SCIENCE

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Calculus	MAT 293F	2	—	2	8
Introduction to Modern Physics	PHY 282F	3	—	1	7
Mechanics of Materials	CIV 204F	3	1½	—	8
Structure of Materials and Metallography	MMS 201F	2	3	1	8
Physical Chemistry I	MMS 202F	2	1	2	8
Non-technical Elective					8
Term 2S					
Calculus and Differential Equations	MAT 294S	2	—	2	8
Probability and Statistics	STA 282S	2	—	2	8
Physical Chemistry II	MMS 203S	2	—	3	8
Metallurgical Chemistry	MMS 204S	2	3	2	9
Materials Science	MMS 205S	4	—	—	7
Non-technical Elective					8
Practical Experience	APS 299	—	—	—	—

THIRD YEAR METALLURGY AND MATERIALS SCIENCE

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations	APM 391F	2	—	2	8
Mineral Processing I	MMS 301F	2	3	—	8
Thermodynamics	MMS 302F	2	—	4	8
Physical Metallurgy	MMS 303F	3	3	—	8
Open Elective					8
one Materials Science elective:⁽¹⁾ ⁽²⁾					
Polymer Engineering	CHE 415F	2	—	1	7
Physical Electronics A	ELE 335F	2	1½	—	6
Physical Electronics I	ELE 350F	2	1½	—	7
Materials Science Laboratory	MMS 331F	—	3	1	8
Term 3S					
Numerical Methods	CSC 236S	2	—	2	7
Transport Phenomena	MEC 349S	3	1½	1½	8
Physics of Metals	MMS 304S	3	3	—	8
Extractive Metallurgy I	MMS 305S	4	3	—	9
Open Elective					8
and one of:⁽¹⁾ ⁽²⁾					
Applied Nuclear Chemistry	CHE 418S	2	—	1	8
Introduction to Nuclear Engineering	CHE 427S	2	—	1	8
Ceramics	CHE 420S	2	—	1	8
Extractive Metallurgy Laboratory	MMS 332S	—	3	1	8

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(1) With the approval of the Chairman of the Department, any other suitable course may be substituted as an elective.

(2) The student should consult with his assigned staff tutor before choosing technical electives. Departmental electives for which there is insufficient demand may be withdrawn.

FOURTH YEAR METALLURGY AND MATERIALS SCIENCE

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Electrical Systems	ELE 470F	3	3	—	9
Extractive Metallurgy II	MMS 401F	2	3	1	8
Solid State Science	MMS 402F	3	3	1	9
Thesis	MMS 499	—	6	—	6
Free Elective					8
and one of:(1) (2)					
Composite Materials	CHE 413F	2	—	1	7
Operational Research I	IND 431F	2	—	2	8
Powder Metallurgy	MMS 431F	2	—	1	8
Term 4S					
Thesis	MMS 499	—	12	—	12
Free Elective					8
two of:(2)					
Electrochemical Processes	MMS 404S	2	—	2	7
Advanced Chemical Metallurgy	MMS 406S	1	—	3	7
Metallurgical Systems Analysis	MMS 407S	2	—	1	7
Mineral Processing II	MMS 412S	2	1½	—	7
two of:(2)					
Materials Engineering	MMS 408S	3	—	—	7
Advanced Materials Science	MMS 411S	3	3	—	8
Solid State Physics	PHY 304S	2	—	—	8
Operational Research II	IND 432S	2	—	2	8

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(1) With the approval of the Chairman of the Department, any other suitable course may be substituted as an elective.

(2) The student should consult with his assigned staff tutor before choosing technical electives. Departmental electives for which there is insufficient demand may be withdrawn.

Geological Engineering

The course in Geological Engineering is an interfaculty course, the specialized core of which is provided by the Department of Geology (Faculty of Arts and Science) with assistance from several departments of the Faculty of Applied Science and Engineering. It is administered by a Course Committee the current members of which are:

E. W. Nuffield, B.A.(B.C.), PH.D., F.R.S.C., *Chairman; Professor and Chairman, Department of Geology.*

C. B. Alcock, B.SC., PH.D., A.R.C.S., D.SC.(LOND.), F.R.I.C., M.I.M.M., *Professor and Chairman, Department of Metallurgy and Materials Science.*

W. D. Baines, B.SC.(ALTA.), M.SC., PH.D.(IOWA), *Professor and Chairman, Department of Mechanical Engineering.*

J. G. Breckenridge, B.A.SC., PH.D.(CANTAB), *Professor of Chemical Engineering.*

J. B. Currie, B.A.(MCM.), M.A., PH.D., *Professor of Geology.*

T. C. Kenney, B.ENG.(MCG.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.), *Professor and Chairman, Department of Civil Engineering.*

H. R. Rice, B.SC.(QUEEN'S), *Professor of Mining Engineering.*

GEOLOGICAL ENGINEERING

Program 9

Geology is the science of the earth. It includes, in a large sense, all knowledge of the earth – its origin, history, structure, composition and mineral wealth – and the physical, chemical and biological processes that change the earth. It spans a wide range of sciences and requires a thorough grounding in mathematics and the basic sciences and engineering disciplines to aid in a proper understanding of the subject and its many applications. Students entering the Second Year of the Program in Geological Engineering are offered a broad curriculum from which they can choose one of the following three options:

Option A, Mineral Exploration, provides a thorough grounding in basic geology including mineralogy, structure, petrology and stratigraphy. In addition it includes courses in Exploration Geochemistry and Geophysics, and in Mineral Deposits, Petroleum Geology and Geohydrology. Students can round out their education with courses in Mining and Mineral Processing, courses dealing with the properties of soils, or courses related to control of the environment.

Option B, Mineral Engineering, which is concerned with the concentration and processing of the valuable contents of the products of mining operations, emphasizes mineralogy in addition to basic physics and chemistry. Students will undertake specialized courses in the subject in the last two years of the Program.

Option C, Engineering Geology, represents the area relating Geology to Civil Engineering, Resource Engineering and Regional Planning. To start with, students take a number of courses in basic geology and engineering. They then can choose from a wide range of courses which qualify them to identify and evaluate the "geological hazards" affecting the design and safety of specific engineering projects and to review regional planning proposals to reduce the destruction of our natural resources and the deterioration of our environment.

The three options have much in common in the Second Year and students may petition for a transfer from one option to another at the end of either Term 2F or Term 2S.

For the First Year curriculum see Division A, page 25.

SECOND YEAR GEOLOGICAL ENGINEERING†

Option A (Mineral Exploration)

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Inorganic Chemistry I	CHE 214F	2	—	—	7
Mineralogy	GLG 220	2	4	—	9
Calculus	MAT 293F	2	—	2	8
Basic Classical and Modern Physics	PHY 283F	3	—	—	8
Non-technical Elective					8
and one of:					
Strength of Materials	CIV 210F	3	—	—	8
Surveying	CIV 255F	3	2	1	9
Engineer and his Environment	CIV 267F	2	2	2	8
Principles of Physical Geology*	GLG 120F	2	3	—	9
Term 2S					
Inorganic Chemistry II	CHE 215S	2	—	—	8
Principles of Historical Geology	GLG 122S	2	3	—	9
Mineralogy	GLG 220	2	4	—	9
Basic Electromagnetism	PHY 284S	1	3	—	7
Non-technical Elective					8

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†Students who intend to take GLG 321F in Third Year (Options A and C) must attend an 8-day field camp immediately following the Term 2S examinations at a cost of about $40 per student.

*This course is required of students who have not taken GLG 180S.

SECOND YEAR GEOLOGICAL ENGINEERING (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
and one of:					
Geological Data Processing by Computer	GLG 221S	1	3	—	8
Calculus and Differential Equations	MAT 294S	2	—	2	8
Probability and Statistics	STA 282S	2	—	2	8
Option B (Mineral Engineering)					
Term 2F					
Mineralogy	GLG 220	2	4	—	9
Calculus	MAT 293F	2	—	2	8
Physics and Chemistry of Materials	MMS 225F	4	—	3	9
Introduction to Modern Physics	PHY 282F	3	—	1	7
Non-technical Elective					8
and one of:					
Strength of Materials	CIV 210F	3	—	—	8
Surveying	CIV 255F	3	2	1	9
Engineer and his Environment	CIV 267F	2	2	2	8
Principles of Physical Geology*	GLG 120F	2	3	—	9
Term 2S					
Principles of Historical Geology	GLG 122S	2	3	—	9
Mineralogy	GLG 220	2	4	—	9
Physical Chemistry	MMS 203S	2	—	3	8
Introductory Metallurgy	MMS 224S	2	—	—	6
Inorganic Chemistry	MMS 226S	2	—	2	8
Non-technical Elective					8
Option C (Engineering Geology)					
Term 2F					
Strength of Materials	CIV 210F	3	—	—	8
Engineer and his Environment	CIV 267F	2	2	2	8
Mineralogy	GLG 220	2	4	—	9
Calculus	MAT 293F	2	—	2	8
Non-technical Elective					8
and one of:					
Surveying	CIV 255F	3	2	1	9
Principles of Physical Geology*	GLG 120F	2	3	—	9
Basic Science course**					

SECOND YEAR GEOLOGICAL ENGINEERING (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
Term 2S					
Engineering Materials	CIV 209S	4	2	1	10
Environmental Systems	CIV 240S	2	—	—	5
Principles of Historical Geology	GLG 122S	2	3	—	9
Mineralogy	GLG 220	2	4	—	9
Non-technical Elective					8
and one of:					
Calculus and Differential Equations	MAT 294S	2	—	2	8
Probability and Statistics	STA 282S	2	—	3	8
Basic Science course**					

*This course is required of students who have not taken GLG 180S.

**Students in Option C must use one of the technical electives in the Second, Third or Fourth Years for a basic science course, see page 23.

THIRD YEAR GEOLOGICAL ENGINEERING†

Option A (Mineral Exploration)

		Lect.	*Lab.*	*Tut.*	*Wt.*
Term 3F					
Survey Camp (Optional)***	CIV 359F	—	—	—	—
Petrology	GLG 320	2	3	—	8
Stratigraphy and Sedimentation	GLG 321F	2	2	—	8
Tectonics	GLG 322	1	3	—	8
Physical Geochemistry	GLG 324	3	—	—	8
Open Elective					8
and one of:					
Soil Mechanics	CIV 321F	2	1	—	6
Mining Technology I	CIV 328F	3	—	1	8
Air Photo Interpretation	CIV 429F	3	—	2	8
Geophysics	PHY 225F	2	—	1	8
Term 3S					
Petrology	GLG 320	2	3	—	8
Tectonics	GLG 322	1	3	—	8
Physical Geochemistry	GLG 324	3	—	—	8
Geology of the Canadian Shield	GLG 327S	2	2	—	8
Open Elective					8

THIRD YEAR GEOLOGICAL ENGINEERING (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
and one of:					
Foundations	CIV 322S	2	1	1	7
Mining Technology II	CIV 329S	2	—	2	8
Pleistocene Geology	CIV 327S	3	2	—	8
Probability and Statistics	STA 282S	2	—	2	8
Calculus and Differential Equations	MAT 294S	2	—	2	8
Introductory Metallurgy	MMS 224S	2	—	—	6
Option B (Mineral Engineering)					
Term 3F					
Differential Equations	APM 391F	2	—	2	8
Mining Technology I	CIV 328F	3	—	1	8
Mineral Processing I	MMS 301F	2	3	—	8
Thermodynamics	MMS 302F	2	—	4	8
Open Elective					8
and one of:					
Mass Transfer Operations I	CHE 312F	2	—	2	9
Soil Mechanics	CIV 321F	2	1	—	6
Physical Geochemistry	GLG 324	3	—	—	8
Materials Science	MMS 222F	3	3	—	8
Term 3S					
Mining Technology II	CIV 329S	2	—	2	8
Numerical Methods	CSC 236S	2	—	2	7
Extractive Metallurgy I	MMS 305S	4	3	—	9
Mineral Processing II	MMS 412S	2	1½	—	7
Open Elective					8
and one of:					
Fundamental Process Modelling and Simulation	CHE 306S	2	—	1	6
Mass Transfer Operations II	CHE 313S	2	—	1½	8
Physical Geochemistry	GLG 324	3	—	—	8
Materials Science	MMS 205S	4	—	—	7

THIRD YEAR GEOLOGICAL ENGINEERING (CONTINUED)

Option C (Engineering Geology)		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Term 3F					
Survey Camp (Optional)***	CIV 359F	—	—	—	—
Soil Mechanics	CIV 321F	2	1	—	6
Stratigraphy and Sedimentation	GLG 321F	2	2	—	8
Tectonics	GLG 322	1	3	—	8
Fluid Mechanics	MEC 351F	3	3	—	10
Open Elective					8
and one of:					
Mining Technology I	CIV 328F	3	—	1	8
Surveying	CIV 255F	3	2	1	9
Air Photo Interpretation	CIV 429F	3	—	2	8
Petrology	GLG 320	2	3	—	8
Geophysics	PHY 225F	2	—	1	8
Term 3S					
Foundations	CIV 322S	2	1	1	7
Pleistocene Geology	CIV 327S	3	2	—	8
Tectonics	GLG 322	1	3	—	8
Geology of the Canadian Shield	GLG 327S	2	2	—	8
Open Elective					8
and one of:					
Mining Technology II	CIV 329S	2	—	2	8
Petrology	GLG 320	2	3	—	8
Calculus and Differential Equations	MAT 294S	2	2	—	8
Introductory Metallurgy	MMS 224S	2	—	—	6
Probability and Statistics	STA 282S	2	3	—	8

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†Students taking GLG 320 or GLG 322 (Options A and C) must attend a 14-day field camp in the Tweed area immediately following the Term 3S examinations. A fee of about $75.00 is levied by the Department of Geology to help offset the cost.

***Survey Camp is offered prior to the commencement of regular courses in Third Year. The results will be included with those for the subsequent term on the basis of a weighting of 8 units.

FOURTH YEAR GEOLOGICAL ENGINEERING

Option A (Mineral Exploration)

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Mineral Deposits	GLG 421	2	3	—	8
Exploration Geochemistry	GLG 422	2	3	—	8
Petroleum Geology	GLG 428F	2	3	—	8
Exploration Geophysics	PHY 308X	2	3	—	8
Free Elective					8
and one of:					
Soil Mechanics	CIV 321F	2	1	—	6
Mine Operation and Administration I	CIV 426F	2	3	—	8
Pollution Control Engineering	CIV 440F	3	—	2	8
Photogrammetry and Remote Sensing	CIV 455F	3	2	—	8
Mineral Processing I	MMS 301F	2	3	—	8
Term 4S					
Mineral Deposits	GLG 421	2	3	—	8
Exploration Geochemistry	GLG 422	2	3	—	8
Thesis	GLG 499S	—	6	—	8
Exploration Geophysics	PHY 308X	2	3	—	8
Free Elective					8
and one of:					
Construction Engineering	CIV 420S	3	—	2	8
Mine Operation and Administration II	CIV 427S	2	3	—	8
Sedimentology	GGR 311S	1	1	2	6
Geohydrology	GLG 429S	2	3	—	8
Mineral Processing II	MMS 412S	2	1½	—	7

Option B (Mineral Engineering) – Terms 4F and 4S will be first offered in 1973–74.
Option C (Engineering Geology) – Terms 4F and 4S will be first offered in 1973–74.

Aerospace Science and Engineering

TEACHING STAFF OF THE INSTITUTE FOR AEROSPACE SCIENCE AND ENGINEERING

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H. S. Ribner, B.S.(CAL. TECH.), M.S.(WASH.), PH.D.(WASH.), F.A.P.S., F.A.S.A., F.C.A.S.I.

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R. M. Measures, B.SC., A.R.C.S., D.I.C., PH.D.(LOND.)

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J. W. Locke, B.A.SC., M.A.SC., PH.D.

L. D. Reid, B.A.SC., M.A.SC., PH.D.

Laboratory Supervisor:

K. Acton, B.SC. TECH., M.E.(MANCHESTER)

AEROSPACE SCIENCE AND ENGINEERING

The University of Toronto offers a broad and coherent program of studies in the aerospace sciences and engineering. It is designed to prepare its graduates for work in a variety of areas including civil air transportation, design and development of new aircraft, spacecraft and air cushion vehicles, and fundamental research in many of the relevant underlying areas of science. Future Canadian needs for air and surface transportation, satellite communications, and survey satellites are significant factors in determining the content of the courses and the research projects undertaken.

The courses of study available comprise a basic 4 year program leading to the B.A.Sc. degree, an additional year leading to the M.Eng. or M.A.Sc. degree, and a subsequent Doctoral program. The undergraduate (Bachelor's) program consists of four years in Engineering Science (option 5A), and the post-graduate programs are taken in the department of Aerospace Science and Engineering of the School of Graduate Studies.

(i) *Undergraduate Program.* The details of the undergraduate program are given in this Calendar (page 41) and are seen to consist mainly of intensive studies in the fundamentals of mathematics, physics, and the engineering sciences. In the final two years the program is oriented to the special needs of the aerospace field, and includes some highly specialized courses. The aerospace-related subjects in these two years are taught by the faculty of the Institute for Aerospace Studies. Graduates of this program are able to fill a variety of positions in education, industry and government, but the fifth year (see below) is recommended for those who wish to improve their qualifications for employment as aerospace engineers.

(ii) *Graduate Program.* If the student's academic record in the undergraduate program meets the requirements for admission to the School of Graduate Studies, he may pursue during a fifth year a program as a candidate for the M.A.Sc. or M.Eng. degree in the (graduate) department of Aerospace Science and Engineering. Details of entrance regulations and courses of study are given in the Calendar of the School of Graduate Studies. The facilities of the Institute for Aerospace Studies are available to the student for research or project work. For details of research fields, assistantships, scholarships and demonstratorships, students should consult the secretary of the graduate department.

It should be noted that a student who has graduated in another branch of engineering, or in science or mathematics, and who desires to qualify as an aerospace engineer may be admitted to the graduate program. In that case the courses leading to the M.A.Sc. or M.Eng. degree will be arranged on an individual basis so that any deficiencies in undergraduate training are made up.

The facilities of the Institute are available for further graduate study and research leading to the Ph.D. degree.

Outline of Courses

On the following pages are brief outlines of the courses prescribed for students in the Faculty of Applied Science and Engineering, listed in alphabetical order of the prefixes (AER, CIV etc.) which identify the teaching department. The suffix following the course number indicates the term in which the course is given; the second line of the description shows the program and year in which the course is prescribed, and the number of hours of lectures, laboratory and tutorial work per week, and the weight units assigned to the course. For example:

MEC 205F Dynamics
II–7 2 – 1 7

indicates a fall-term course offered by the Department of Mechanical Engineering for students in Second Year Electrical Engineering. The course consists of 2 hours lectures, no laboratory, and 1 hour tutorial per week, and has a weight of seven units.

Many course descriptions include a statement of prerequisites and corequisites for the information of students, but the absence of such a statement does not imply that the course does not have prerequisites.

Interpretation of suffixes to course numbers:*

F: a first-term course.
S: a second-term course.
F/S: indicates that the course given in the Fall Term is repeated in the Spring Term; a student may take one or the other, but not both.
C: the first half of a full year course taken in the Faculty of Arts and Science; Engineering students will be evaluated at the end of the first term.
D: the second half of the above. (Both parts of the course must be taken.)
X: when added to a course offered in the Faculty of Arts and Science, signifies that a laboratory course with a different number has been added for Engineering students.
Y: a half-course in the Faculty of Arts and Science given over a full year.

*The absence of a suffix indicates that the course continues over both terms.

AEROSPACE

AER 301F MECHANICS

III – 5a, 5g, 5nt, 5p 3 – 1½ 8

Mechanics of particles: fixed axes, rotating and moving axes, orbital dynamics, rockets. Mechanics of rigid bodies: fixed axes, body-attached axes, gyroscopes. Mechanics of linear systems: free and forced oscillations, coupled systems, waves on a string. Rayleigh's method. Lagrange's equations. Special topics by request. Primary Reference: class notes. Reference books: Introduction to Theoretical Physics – Page. Principles of Mechanics – Synge and Griffith. Dynamics, Vols. I and II – Halfmann.

H. S. Ribner

AER 302F MECHANICS OF STRUCTURES

III – 5a 3 – 1½ 8

Basic theorems and principles in the theory of structures (strain energy, virtual displacements, minimum total potential energy). General theory of bending of beams (unsymmetrical bending, thin walled structures, shear flow in multiflanged beams, open and closed sections). General theory of torsion (thin walled structures, multicell structures, shear centre). Theory of elastic instability (buckling of slender elastic struts, flat and curved plates, shells). Plane stress problems (Airy and Prandtl stress functions).

R. C. Tennyson

AER 303F AEROSPACE LABORATORY I

III – 5a – 3 – 8

Students will perform some prepared experiments and/or carry out an individual project in the subject areas Mechanics and/or Mechanics of Structures.

K. Acton

AER 304S AEROSPACE LABORATORY II

III – 5a – 3 – 7

Students will perform some prepared experiments and/or carry out an individual project in the subject area Fluid Mechanics.

K. Acton

AER 305S FLUID MECHANICS

III – 5a 3 – 1½ 8

Introductory concepts and idealizations of real fluids; mathematical theory of incompressible inviscid flow; viscous flow and turbulence. Reference Books: *Fundamentals of Hydro and Aeromechanics* – Prandtl and Tietjens; *Applied Hydro and Aeromechanics* – Prandtl and Tietjens; *Fluid Dynamics* (1948 ed.) – Streeter. Advanced reading: *Hydrodynamics* – Lamb; *Incompressible Aerodynamics* – Thwaites.

J. W. Locke

AER 401F AERODYNAMICS

IV – 5a 3 – 1½ 9

Aerodynamics of Flight: drag, propulsion, wing theory. Mechanics of flight: performance of aircraft, stability and control of aircraft. Reference Books: *Aerodynamics of V/STOL Flight* – B. W. McCormick, Jr.; *Foundations of Aerodynamics* – Kuethe and Schetzer. *Flight Mechanics – I: Theory of Flight Paths* – A. Miehle; *Dynamics of Flight – Stability and Control* – Etkin.

J. H. De Leeuw

AER 402F SPACE FLIGHT DYNAMICS

IV – 5a 2 – 1½ 8

Kepler's problem; time of flight; Lambert's problem; trajectory design; coordinate systems and orbital elements; orbit determination; impulse thrust approximation; patched conic approximation; manoeuvres; three-body problem; lunar trajectories; rigid body in torque-free motion; gravity-gradient potential; librations of rigid body in circular orbit; spinning rigid body in circular orbit; dissipation effects; effects of structural flexibility; dynamics of planetary entry.

P. C. Hughes

AER 403F ADVANCED MECHANICS OF STRUCTURES

IV – 5a 2 – 1½ 8

Matrix analysis of redundant structures is studied, including the force and displacement methods. Flexibility and stiffness matrices for structural elements are derived and solutions given for the effects of thermal strains and structural cutouts. Automated techniques for determining redundant members are presented. The finite element approach is derived and applied to plates and shells. The method of individual displacements is also considered with solutions given for buckling loads, natural frequencies and stress distributions in structures. Reference Books: *Theory of Matrix Structural Analysis* – J. S. Przemienicki, McGraw-Hill, New York (1968). *The Finite Element Method in Structural and Continuum Mechanics* – Zienkiewicz, O. C., and Cheung, Y. K., McGraw-Hill, London (1967).

R. C. Tennyson

AER 404F PHYSICS AND MECHANICS OF SOLIDS

IV – 5a 3 – 1½ 9

Properties of solids, the factors on which they depend. Structural imperfections, atom movements, dislocation theory. Deformation and failure of metals. Metal fatigue, service loads and service load laboratory simulation, statistical evaluation of fatigue data. Microstructural changes in metal due to fatigue, fatigue damage accumulation, crack initiation and propagation. Environmental effects on service life under fatigue, surface protection. Reference Books: *Elements of Materials Science* –

Van Vlack. *Inelastic Behaviour of Engineering Materials and Structures* – Freudenthal.

G. K. Korbacher

AER 405F PLASMADYNAMICS

IV – 5a 3 – 1½ 9

Electrostatics, magnetostatics, Maxwell's equations, E-M wave propagation, plasma equations of motion and conduction, MHD approximation, tensor conductivity, Alfvén, magnetoacoustic and MHD shock waves, simple flow problems in magnetogasdynamics, applications to propulsion and power generation. Reference Books: *Engineering Magnetohydrodynamics* – Sutton and Therman. *The electromagnetogasdynamics of Fluids* – Hughes and Young. *Magnetofluidmechanics* – Cambel. *MHD Power Generation: Engineering Aspects* – Womack.

S. J. Townsend

AER 406F ENGINEERING DESIGN I

IV – 5a – 3 – 8

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Drawings and reports are prepared as required.

L. D. Reid

AER 407S ENGINEERING DESIGN II

IV – 5a – 3 – 7

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Drawings and reports are prepared as required.

L. D. Reid

AER 408F AEROSPACE LABORATORY III

IV – 5a – 6 – 8

Students will perform some prepared experiments and/or carry out an individual project on an approved topic.

K. Acton

AER 409S AEROSPACE LABORATORY IV

IV – 5a – 6 – 7

Students will perform some prepared experiments and/or carry out an individual project on an approved topic.

K. Acton

AER 410S GASDYNAMICS

IV – 5a 3 – 1½ 9

Some fundamental phenomena that occur in a compressible flow are treated. Basic thermodynamics and the equations of inviscid and viscous compressible flows are reviewed. Compressible flow in nozzles, diffusers, and ducts with viscous and diabatic effects, and shock and expansion waves in both steady and nonstationary flows including high temperature effects that cause departures from the perfect gas law and equilibrium, are discussed. Reference Books: *Elements of Gasdynamics* – Lipemann and Roshko. *Dynamics and Thermodynamics of Compressible Fluid Flow* – Shapiro. *Handbook of Supersonic Aerodynamics, Section 18, Shock Tubes* – Glass and Hall. *Introduction to Physical Gasdynamics* – Vincenti and and Kruger.

I. I. Glass

AER 411S STABILITY AND CONTROL OF AIRCRAFT

IV – 5a 2 – 1½ 8

Introduction to the dynamic stability and control-response of aircraft. Equations of mation for small perturbations from steady flight; longitudinal stability; lateral stability; response to throttle, elevator, aileron, rudder; flight in turbulence. *Reference* Book: *Dynamics of Flight-Stability and Control* – Etkin.

B. Etkin

AER 412S AEROELASTICITY

IV – 5a 2 – 1½ 8

Static aeroelastic phenomena are studied, including divergence of slender wings, the effect of low aspect ratio, sweep and wing-aileron interaction. Various methods of solution are considered such as closed form, matrix format iteration and the Rayleigh-Ritz approach. A study of vibration and flutter of wings and control surfaces is presented with particular emphasis on those parameters which affect flutter speed. Reference Books: *An Introduction to The Theory of Aeroelasticity*, Fung, Y. C., Dover Paperback Publications (1969).

R. C. Tennyson

AER 413S PHYSICS OF RADIATING GASES

IV – 5a 3 – – 9

Review of atomic and spectroscopic theory, line radiation, Einstein coefficient, optical depth, population inversion and lasers, applications of lasers, spectral line broadening, local thermodynamic equilibrium, plasma spectroscopic techniques, vibration and rotation of molecules.

R. M. Measures

AER 414S ACOUSTIC THEORY AND NOISE CONTROL

IV – 5a, 7 (elective) 2 1½ – 8

Basic acoustic theory including acoustic plane waves in infinite medium, real fluid effects, radiation of sound in three dimensions, sound propagation in ducts, and architectural acoustics. Noise control theory including transmission and radiation of sound by solid structures, mufflers, filters, resonators, enclosures and porous lining, sound propagation outdoors, subjective response to noise and industrial sources.

H. S. Ribner, G. W. Johnston

APPLIED MATHEMATICS

APM 391F DIFFERENTIAL EQUATIONS

III – 8, 9, III – 4 (elective) 2 – 2 8

First and second order ordinary differential equations, operational methods, variation of parameters, solution in series. Bessel and Legendre functions, the Laplace transform. (Prerequisite MAT 294S)

F. V. Atkinson

APM 393F DIFFERENTIAL EQUATIONS I

III – 5 3 – – 8

Ordinary differential equations, matrix linear systems, qualitative properties of solutions, stability, asymptotic behaviour, nonlinear systems, calculus of variations, Sturm-Liouville problems, separation of variables.

APM 441F DIFFERENTIAL EQUATIONS II

IV – 5 3 – – 8

Partial differential equations of second order, generalized functions, Fourier transforms, wave, diffusion and harmonic equations, Green's functions, eigenvalues and eigenfunctions, variational properties, cylindrical and spherical functions with applications.

APM 446S APPLIED FUNCTIONAL ANALYSIS

IV – 5 3 – – 8

Hilbert and Banach spaces, with applications, dual spaces, linear operators, elements of spectral theory, extremal problems, integral and functional equations, nonlinear operators, stochastic differential equations.

APPLIED SCIENCE AND ENGINEERING — INTERDEPARTMENTAL

APS 100F & S COMPUTER PROGRAMMING

I – 1, 3, 4, 6, 7, 8, 9 1 – 3 7

The digital computing system as a device for numeric and non numeric transformation of numbers and symbols. Constants, variables, and arrays; arithmetic and logical expressions; functions. Algorithms, represented by flow chart and computer languages. Conditional branching and looping; iteration; sub-programs; input/output. All of the above will be illustrated and implemented using the FORTRAN IV language. Applications will include root finding, numerical integration, sorting, iterative design and graph plotting.

APS 101S ENGINEERING DESIGN

I – 1, 3, 4, 5, 6, 7, 8, 9 (elective) 2 1 1½ 8

Lectures will deal with the sequence of design steps by which engineers find acceptable solutions for stated technological needs. These include need definition, ideation, problem modelling, feasibility and economic analysis, the decision process, specification and presentation. A series of seminars will be used to study "case" problems and to consider such topics as the engineer's responsibility to society. Laboratory time will be devoted to small group design projects.

APS 201S ENGINEERING DESIGN

II – 5 (elective) – – 6 8

This course provides instruction and experience in the application of engineering design techniques that lead from a stated technological need to an acceptable solution. Students will work singly or in small groups on design projects and will have lecture/discussion sessions on problem identification, ideation, design criteria, feasibility analysis and decision making. Special topics related to the projects, such as materials, economics, reliability, etc., will be covered as required. At least one of the projects will be carried through to the drawing and specification stage and, if possible, constructed. Class size is limited to twenty students. Reference Books: *An Introduction to Engineering & Engineering Design*, second edition, E. V. Krick, John Wiley and Sons. *Introduction to Engineering Design*, T. T. Woodson, McGraw-Hill.

APS 299 PRACTICAL EXPERIENCE

Students in the programs listed below are required to have, before graduation, practical work of a nature acceptable to the department concerned. This may be obtained during the summer vacations but work done before entering the Faculty may also meet the requirements. Instructions will be issued by the departments concerning the type of work which is acceptable. Practical experience certificate forms may be obtained from the departments and should be returned there when completed.

Program 1	600 hours	Program 8	600 hours
Program 6	600 hours	Program 9	600 hours

APS 300F & S ENGINEERING LAW

II – 3, IV – 3, 4 1 – – 2

A course designed to co-ordinate the practice of engineering and law. Consideration is given to the characteristics, advantages and disadvantages of companies, partnerships, the promotion, organization and financing of companies, the duties of employees to employers, the duties and liabilities of engineers, statutes applicable to engineering works, professional engineering associations, construction contracts, workmen's compensation, trade unions and industrial disputes. Reference Book: *Engineering Law* – Laidlaw, Young, and Dick.

E. S. Langdon, W. O. C. Miller

APS 401 PROJECT DESIGN

IV – 1, 3, 4, 5, 6, 7, 8 (elective) – – 5 8

This elective, limited to about twenty participants, provides an unusual opportunity for small interdisciplinary student design groups to seek and test solutions for engineering problems with social relevance. Considerable freedom is given in self-structuring of the groups and selection of the problems. Emphasis is placed on management of the design activity and on group effectiveness. Similar topics and instruction are selected to support the particular needs of the groups. Building and testing of prototypes, when applicable, is encouraged; written and oral presentation, with discussion of results, is required.

Permission to substitute this course for other electives and/or for thesis must be obtained from the student's department before being accepted into it. Further details may be obtained from Professor I. W. Smith or Professor M. Townsend.

APS 420S URBAN AND REGIONAL PLANNING

III – 1 (elective); IV – 1 (elective) 3 – 2 8

Spatial distribution of land use related to physical, ecological and transportation factors. Economic alternatives for the selection of industrial, residential and recreational location. Land use planning concerning natural resources, resource potential and conservation. Legal aspects of planning. Mathematical modelling and optimization of land use. (To be offered jointly by the Departments of Urban and Regional Planning and Civil Engineering.)

APS 478, 479, 495, 496, 497S, 498S, 499 THESIS IV-5

Every student in fourth year Engineering Science is required to prepare a thesis on an approved subject. Instructions concerning the thesis requirements are issued during the spring term of third year, and copies may be obtained in the division office. The weight allocated in each term of each option is shown in the fourth year curriculum.

The thesis will be graded after submission in the spring term, and the grade included in the weighted average for that term only. The weight assigned will be the sum of the weights for both terms.

CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

CHE 100F CHEMISTRY

I – 1, 3, 4, 6, 7, 8, 9 3 3 1 12

An introductory course in physical chemistry involving problems dealing with industrial and engineering applications. Topics discussed are stoichiometry and the mole concept, ideal and real gas behaviour, phase equilibria and colligative properties of solutions, chemical and ionic equilibrium, electrochemistry, thermochemistry and chemical kinetics.

The lecture course is supplemented by a series of laboratory experiments illustrating the principles discussed. Experiments include a gas-chromatographic study of fuel combustion, caustic-chlorine and sulphuric acid pilot plants, freezing point depression, molecular weight determination, vapour pressure, steam and binary distillations, qualitative analysis, heat of neutralization, kinetics, corrosion, pH and electrochemistry.

S. Sandler and Staff in Chemical Engineering

CHE 101S CHEMICAL ENGINEERING PROJECTS

I – 1, 3, 4, 5, 6, 7, 8, 9 (elective) – – – 8

A course concerning several topics of wide interest to engineers, in which each student may choose *three* Chemical Engineering Projects during the term. Each five week project is given by a specialist in his field of interest and includes laboratory sessions during which the student may design and execute a particular investigation related to the lecture course. Some of the projects include:

Rheology
Nuclear Kinetics
Composite Materials
Polymer Engineering
Plastics Engineering
Ceramics Engineering
Biochemical Engineering
Combustion
Concepts in Fluid Flow
Separation Processes
Electrolysis
Electrochemical Energy Sources
Environmental Chemistry
Catalysis
Ecological Application of Inorganic Chemistry

A topic will be given in any year in which more than 20 students elect to take it.

R. T. Woodhams and Staff in Chemical Engineering

CHE 102F CHEMISTRY

I – 5 3 3 1 10

CHE 100F with alternative assignments.

W. H. Burgess and Staff in Chemical Engineering

CHE 201F PHYSICAL CHEMISTRY I

II – 6 2 – – 5

The following topics are treated: equations of state, principle of corresponding states, reaction stoichiometry, first law of thermodynamics and thermochemistry, phase equilibrium and phase diagrams.

R. W. Missen

CHE 202S PHYSICAL CHEMISTRY II

II – 6 2 3 – 8

This course provides an introduction to chemical thermodynamics and chemical kinetics. The second law of thermodynamics is discussed and applied to solutions, phase equilibrium, reaction equilibrium, including cell reactions and surfaces; in kinetics attention is focussed on ideal reactor models, rate laws, reaction mechanisms and catalysis. Laboratory work involves experiments for both 201F and 202S.

R. W. Missen

CHE 203F ANALYTICAL CHEMISTRY LABORATORY

– – – –

A voluntary course beginning August 23 is offered by the Senior Staff in the Department of Chemical Engineering and Applied Chemistry. The course is designed to provide experience in precise analytical measurements. Problems relevant to industry and the ecological environment will be examined. Application should be made to the Chairman of the Department by April 30.

J. W. Smith and Senior Staff in Chemical Engineering

CHE 204F ANALYTICAL CHEMISTRY

II – 6

2 10½ – 14

Experimental work and lectures to illustrate the principles of equilibrium and coordination chemistry as applied to quantitative and qualitative analysis. Students may elect an independent experimental project under the direction of a staff member after completing a minimum number of set experiments. Textbooks: *Quantitative Chemical Analysis* – Fischer and Peters.

J. W. Smith and Staff in Chemical Engineering

CHE 205F INDUSTRIAL PROCESS OPERATIONS I

II – 6

3 – 2 9

The theory of momentum and heat transfer and the fundamentals of momentum, heat and mass balances of chemical engineering practice are discussed. A tutorial problem class accompanies this course. Textbooks: *Principles of Unit Operations* – Faust et al. *Basic Principles and Calculations in Chemical Engineering* – Himmelblau.

I. H. Spinner, W. G. MacElhinney

CHE 206S INDUSTRIAL PROCESS OPERATIONS II

II – 6

3 6 2 13

The fundamentals of transfer processes are discussed with particular reference to heat transfer operations in chemical engineering. A laboratory illustrating the principles and practice of transfer operations is also given. A tutorial problem class accompanies the lecture material. Textbooks: *Principles of Unit Operations* – Faust et al. *Unit Operations of Chemical Engineering* – McCabe & Smith.

W. G. MacElhinney, J. W. Smith, I. H. Spinner

CHE 207S ORGANIC CHEMISTRY

II – 6

3 3 – 10

An introductory lecture and laboratory course in organic chemistry, with emphasis on structure. Textbook: *Modern Organic Chemistry* – Griffin.

W. H. Rapson

CHE 208S APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

II – 6 2 – 1 6

Application of differential equations to problems of chemical engineering interest. Emphasis is on the formulation of differential equations together with their solution by analytical and numerical methods. Reference Book: *Applied Differential Equations* – M. R. Spiegel.

R. Luus

CHE 209F CHEMICAL SYSTEMS

II – 5 3 3 – 8½

The themes discussed are conservation, equilibrium and rate of change in chemical systems. These are applied to topics in various engineering fields. Laboratory work illustrating the principles with emphasis on individual projects accompanies the lectures.

C. E. Chaffey

CHE 214F INORGANIC CHEMISTRY I

II – 9a 2 – – 7

CHE 217F with alternative assignments. *R. E. Jervis*

CHE 215S INORGANIC CHEMISTRY II

II – 9a 2 – – 8

CHE 218S with alternative assignments.

R. L. Hummel

CHE 217F INORGANIC CHEMISTRY I

II – 6 2 – – 5

Periodicity in physical and chemical properties of the elements are studied in relation to atomic structure. Descriptive chemistry of representative and some transition elements are correlated with structure. Textbook: *University Chemistry* – Mahan (second ed.).

R. E. Jervis

CHE 218S INORGANIC CHEMISTRY II

II – 6 2 – – 5

Useful quantum models are developed for atoms and for atomic and molecular orbital bonding mechanisms. Concepts discussed include: electronegativity, Z-effective, ionic compounds, covalent bond lengths and energies, partial ionic character of bonds, co-ordination and complexation.

R. L. Hummel

CHE 301F THERMODYNAMICS AND KINETICS I

III – 6 3 6 2 14

The power sources which have supported our civilization are ultimately based on the exploitation of chemical potentials. This course is an examination of the ultimate energy transformation and the rates at which they may be provided, together constituting a complete description of the Gibbsian power sources.

Laws of conservation and the concept of entropy together with theories of chemical reaction rates and mechanisms of selected chemical processes will be discussed in an historical context. These concepts will be illustrated by chemical engineering problems encountered in the design and operation of the means of production.

W. F. Graydon, W. H. Burgess

CHE 302S THERMODYNAMICS AND KINETICS II

III – 6 3 6 2 14

A re-statement of the material described in course CHE 301F with additional quantitative applications taken from Chemical Engineering practice.

W. F. Graydon, W. H. Burgess

CHE 303F THERMODYNAMICS AND KINETICS I

III – 5a, c 2 3 – 9

Course 301F with reduced laboratory or tutorial assignments.

W. F. Graydon

CHE 304S THERMODYNAMICS AND KINETICS II

III – 5c 2 3 – 9

Course 302S with reduced laboratory or tutorial assignments.

W. F. Graydon

CHE 305F APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

III – 6 2 – 1 6

Analysis and solution of chemical engineering problems which require knowledge of the rational design of experiments, treatment of experimental data and tests of hypotheses. The application of probability to selected topics of chemical engineering interest. Reference Books: *Probability and Statistics for Engineers* – I. Miller and J. E. Freund. *Engineering Statistics* – Bowker and Lieberman.

I. H. Spinner

CHE 306S FUNDAMENTAL PROCESS MODELLING AND SIMULATION

III – 6, 9B (elective) 2 – 1 6

Modelling of elementary chemical engineering processes leading to differential equations and arising from the application of the principles of thermodynamics, kinetics, fluid mechanics, and heat and mass transfer to chemical engineering problems.

D. Basmadjian, M. E. Charles, I. H. Spinner

CHE 307S ORGANIC CHEMISTRY OF HIGH POLYMERS

III – 6 (elective) 2 – 1 6

Organic high polymers can be prepared by various mechanisms which are extensions of the organic chemical reactions studied earlier. Free radical, cationic, anionic and coordination complex catalysts produce different polymers with appropriate monomers.

The nature and kinetics of these reactions are discussed. The products have a molecular weight distribution and the means of measuring this and certain other properties used to characterize polymers are included. Reactions of polymers to build substituted, grafted or reticulated structures are included to illustrate the suprastructural aspects.

W. H. Rapson, H. L. Williams, R. T. Woodhams, I. H. Spinner

CHE 308S CHEMICAL ENGINEERING ECONOMICS

III – 6 (elective) 2 – 1 6

A systems approach to the feasibility of chemical engineering projects. The objectives, profitability, probability profiles, benefit-cost and social risk analyses are discussed, as are criteria for engineering decision-making, responsibilities of engineers in project implementation and range of typical Canadian and overseas engineering problems. Textbook: *Plant Design and Economics for Chemical Engineers* – Peters and Timmerhaus. Reference Book: *Fundamentals of Cost Engineering in the Chemical Industry* – Bauman.

M. Wayman

CHE 309F ORGANIC CHEMISTRY II

III – 6 3 9 – 14

A continuation of course 207S. Textbook: *Modern Organic Chemistry* – Griffin.

J. G. Breckenridge

CHE 310F MASS TRANSFER OPERATIONS I

III – 6 2 – 2 8

The study of the fundamentals of mass transfer. Theory and practice of applications to gas-liquid mass transfer processes, including gas absorption, stripping, drying and humidification. Textbook: *Mass Transfer Operations*, 2nd ed. – R. E. Treybal.

D. Mackay, O. Trass, R. F. Hunter

CHE 311S MASS TRANSFER OPERATIONS II

III – 6 2 4½ 1 11

The study of distillation, including extractive and azeotropic distillation, solvent extraction, adsorption, membrane separation and other separation processes. Illustrative laboratory experiments. Textbook: *Mass Transfer Operations*, 2nd ed. – R. E. Treybal.

D. Mackay, O. Trass, R. F. Hunter

CHE 312F MASS TRANSFER OPERATIONS I

III – 5c 2 – 2 9

Course 310F but with alternative assignments.

D. Mackay, O. Trass, R. F. Hunter

CHE 313S MASS TRANSFER OPERATIONS II

III – 5c; 9B (elective) 2 – 1½ 8

Course 311S with no laboratory assignments, and alternative tutorial assignments.

D. Mackay, O. Trass, R. F. Hunter

CHE 314S FLUID MECHANICS

III – 6 3 1½ 1 10

Laminar and turbulent flow of Newtonian and non-Newtonian fluids, fluid-particle systems, two-phase flow, pumps; important application of fluid mechanics in the process industries and the environment.

M. E. Charles

CHE 315F CHEMICAL ENGINEERING PROBLEMS AND LABORATORY I

III – 5c – 2 – 7

Laboratory experiments and problems illustrating selected topics discussed in subject CHE 301F.

W. F. Graydon

CHE 316S CHEMICAL ENGINEERING PROBLEMS AND LABORATORY II

III – 5c – 2 – 7

Laboratory experiments and problems illustrating selected topics discussed in subjects CHE 302S and CHE 317S.

W. F. Graydon

CHE 317S MOLECULAR ENGINEERING

III – 5c 3 – – 8

A basic course in organic and inorganic chemistry which emphasizes the fundamental mechanisms of chemical reactions and catalysis with reference to their use in industrial processes.

R. T. Woodhams

CHE 402F CHEMICAL ENGINEERING THERMODYNAMICS

IV – 6 (elective) 2 – 1 7

Thermodynamic properties of real gases and of ideal and non-ideal liquid solutions. Chemical reaction equilibria. Selected problems.

W. H. Burgess

CHE 403F INTERFACE KINETICS

IV – 6 (elective) 2 – 1 7

A course on the chemical kinetics of catalytic processes.

W. F. Graydon

CHE 404S MOLECULAR THERMODYNAMICS

IV – 6, IV – 5c (elective) 2 – 1 8

The application of thermodynamics together with simple molecular considerations to the description and prediction of equilibrium behaviour in chemical systems, including the Principle of Corresponding states, real-gas behaviour, solutions of non-electrolytes, and phase and reaction equilibria. Reference books: *The Principles of Chemical Equilibrium*, 3rd edition – K. G. Denbigh, *Molecular Thermodynamics of Fluid Equilibria* – J. M. Prausnitz.

R. W. Missen

CHE 405F CHEMICAL PLANT DESIGN

IV – 6 (elective) – – 6 7

This is a course based on synthesis and creativity. Teams of about 6 students each design and cost a chemical plant. The plants are chosen based on current Canadian needs and interests.

M. Wayman

CHE 406F CHEMICAL PLANT DESIGN

IV – 5c (elective) – – 6 9

CHE 405F with alternative assignments. *M. Wayman*

CHE 407F PROCESS MODELLING AND SIMULATION

IV – 6 (elective) 2 – 3 7

The mathematical modelling of steady and unsteady states in typical processes involving fluid flow, heat and mass transfer, vapour-liquid equilibria, and chemical reaction. Solution by analytical, analog and digital methods.

D. Basmadjian, M. E. Charles, I. H. Spinner

CHE 408F STRATEGY OF PRODUCT AND PROCESS DEVELOPMENT

IV – 6 (elective) 2 3 – 7

The strategical approaches needed for the solution of engineering problems involving the creation of novel unit operation equipment and novel processes, both for chemical and non-chemical products.

R. F. Hunter, I. H. Spinner

CHE 409F STRATEGY OF PRODUCT AND PROCESS DEVELOPMENT

IV – 5c (elective) 2 3 – 9

CHE 408F with alternative assignments. *R. F. Hunter, I. H. Spinner*

CHE 410F ADVANCED SEPARATION PROCESSES

IV – 6 (elective) 2 – 1½ 7

Theory and application of a number of separation processes, including multicomponent distillation (using computational techniques), azeotropic and extractive distillation, liquid extraction, transient behaviour and cyclic processes, and solid-liquid contacting operations. Illustrative design problems.

D. Mackay, O. Trass

CHE 411F CONVECTIVE HEAT AND MOMENTUM TRANSFER

IV – 6 (elective) 2 – 1½ 7

A continuation of earlier courses on convective heat and momentum transfer in flowing fluids. A phenomenological approach based on current research. The effect of factors such as roughness is considered in detail.

J. W. Smith

CHE 412F PIPELINE TRANSPORTATION

IV – 6 (elective) 2 – 1½ 7

A course based on the theory and practice of moving gases, liquids and solids by pipeline both within chemical plants and over long distances. Operating pipeline systems are used as examples, and the course includes a feasibility and design study.

M. E. Charles

CHE 413F COMPOSITE MATERIALS

IV – 6, 8; III – 5m (elective) 2 – 1 7

A course on the fundamentals of composite material design, fabrication and evaluation. Topics will emphasize recent developments in the reinforcement of plastics and metals using fibers, flakes, and other particulate fillers. Examples will include the use of such composites in automotive, marine, aircraft, building construction and allied engineering applications.

M. R. Piggott, R. T. Woodhams

CHE 415F POLYMER ENGINEERING

IV – 6; III – 5m, 8 (elective) 2 – 1 7

The solid state properties of polymers are discussed, particularly amorphous state and crystallinity. The rheological and viscoleastic properties are then outlined and the effect on these of degradation and failure mechanisms included. A large segment of the course applies to fabrication techniques, their principles, and the products produced. The over-all emphasis is on the relationship of the properties to the structure, and how these affect the uses.

H. L. Williams

CHE 417F PULP AND PAPER CHEMISTRY, TECHNOLOGY AND ENGINEERING

IV – 6; III – 8 (elective) 2 – 1 8

The chemistry of wood in relation to pulping, bleaching and papermaking processes, the equipment involved and the economics of converting wood into paper.

W. H. Rapson

CHE 418S APPLIED NUCLEAR CHEMISTRY

IV – 6; III – 8 (elective) 2 – 1 8

An introduction to the principles and methods of radioisotope chemistry. Applications of nuclear techniques and radioactive materials in chemical technology and in nuclear power generating systems. Topics to be covered include: radioisotope methods of studying chemical reaction mechanisms and kinetics, chemical process development and process control, nuclear reactions applied to chemical analysis (activation analysis), radiation chemical processing.

R. E. Jervis

CHE 420S CERAMICS

IV – 6, 8 (elective) 2 – 1 8

An introduction to the field of ceramics, including a description of the available raw materials, the production of refractories and glasses, and high-temperature experimental techniques.

D. Barham

CHE 422S CO-ORDINATION CHEMISTRY

6 (elective) 2 – 1 8

The fundamental principles underlying co-ordination compounds: bonding, geometry and isomers, stability, etc., leading to an understanding of examples such as chlorophyll and sequestering agents.

J. G. Breckenridge

CHE 423S ENVIRONMENTAL ENGINEERING

6 (elective) 2 – 1 8

Strategy (management, law, economics) and technology for environmental control of chemical processes. Dispersion and effects of effluents in the environment.

C. R. Phillips

CHE 425S INSTRUMENTAL METHODS

6 (elective) 2 – 1 8

The subject is designed to emphasize the science of chemical instrumentation. The principles, techniques, and applications of gas-chromatographic, opticometric, electrometric and mass-spectometric methods of analysis are studied.

S. Sandler

CHE 426S CHEMICAL BONDING

6 (elective) 2 – 1 8

Periodicity and trends in physical and chemical properties of the compounds of the principal elements are discussed. These are correlated, predicted and classified both in terms of classical concepts and equations of quantum mechanics.

R. L. Hummel

CHE 427S INTRODUCTION TO NUCLEAR ENGINEERING

IV – 6, III – 8 (elective) 2 – 1 8

Nuclear engineering aspects of: nuclear constitution and properties including cross-section, energetics, radioactivity, production and use of radio-isotopes, neutrons, slowing-down, diffusion of thermal neutrons, fission, the fission reactor. Applications of heat transfer to the reactor core; measurements and control of radiation, exposure of humans to radiation, shielding techniques, reactor kinetics, instrumentation and control.

D. G. Andrews, J. S. Hewitt

CHE 429S INTRODUCTION TO NUCLEAR ENGINEERING

IV – 7 (elective) 2 1½ 1 8

CHE 427S with alternative assignments.

CHE 430S INTRODUCTION TO NUCLEAR ENGINEERING

IV – 5e (elective) 2 1½ – 8

CHE 427S with alternative assignments.

*CHE 431S OPTIMAL CONTROL

IV – 6 (elective) 2 – 1 8

Fundamentals of optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: *Optimal Control of Engineering Processes* – Lapidus and Luus.

R. Luus

CHE 432F CHEMICAL REACTORS

IV – 6 (elective) 2 – 1 7

An introduction to the rational design and analysis of chemical reactors. Topics are: chemical kinetics and development of the rate law, including homogeneous and heterogeneous systems and catalysis; reactor models (batch, tubular, stirred-tank), including isothermal, non-isothermal and adiabatic operation. Reference Books: *Chemical Reactor Theory* – K. G. Denbigh, *Chemical Reaction Engineering* – O. Levenspiel.

R. W. Missen

*Not offered in 1972–73

CHE 433S INTERFACIAL PHENOMENA AND DISPERSE SYSTEMS

IV – 6 (elective) 2 – 1 8

A course in surface chemistry, interfacial phenomena and disperse systems (aerosols, emulsions, colloids, surface films, etc.) with chemical engineering applications. Textbook: *Interfacial Phenomena* – Davies, J. F. and Rideal, E. K.

C. R. Phillips

CHE 434S CHEMISTRY OF ORGANIC COMPOUNDS

IV – 6 (elective) 2 – 1 8

A course based on the structures, reactions and properties of carbohydrates, proteins, lipids, dyes and steroids including the toxicology of some industrial organic compounds.

P. Y. Wang

CHE 435F RATE PROCESSES I

IV – 5c 3 – – 9

Introduction to momentum, heat and mass transfer. Transport properties from kinetic theory of gases. Fluid flow concepts, integral mass, force and energy balances, Bernoulli's equation, friction. Equations of motion and boundary layer equations. Turbulent transport. Compressible flow.

O. Trass

CHE 436S RATE PROCESSES II

IV – 5c 3 – – 9

Total energy and thermal energy equations. Heat Transfer: Fourier's laws, heat transfer coefficients and equations. Component mass balances, mass transfer coefficients and Fick's laws. Momentum, heat and mass transfer analogies. Applications of the above fundamentals.

O. Trass

*CHE 437F OPTIMAL CONTROL OF CHEMICAL SYSTEMS

IV – 5c (elective) 3 – 1½ 9

Fundamentals to optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: *Optimal Control of Engineering Processes* – Lapidus and Luus.

R. Luus

*Not offered in 1972–73

CHE 439S SELECTED TOPICS IN ORGANIC CHEMISTRY

IV – 5c (elective) 3 – – 9

A short course in the preparation, structure, and reactions of carbohydrates, proteins, heterocyclic compounds, chemotherapeutic agents, steroid hormones, alkaloids, and synthetic organic polymers.

P. Y. Wang

CHE 440S MODELLING AND SIMULATION OF CHEMICAL SYSTEMS

IV – 5c (elective) 3 – – 9

Applications of elements of chemical and physical rate processes to chemical engineering problems. Chemical reactor stability, complex chemical system dynamics and process control. Application of analog, digital simulation, and hybrid computers to the solutions of problems in the above topics.

I. H. Spinner

CHE 441F CHEMICAL ENGINEERING PROJECT

IV – 5c (elective) – 6 – 9

An experimentally oriented research project.

Senior Staff in Chemical Engineering

CHE 442F NUCLEAR ENGINEERING

IV – 5nt 3 3 – 11

Nuclear engineering aspects of: nuclear constitution and properties, including cross-section, energetics, radioactivity, production and use of radio-isotopes, neutrons, slowing down, "age" theory, diffusion of thermal neutrons, fission. The age and two-group theories of the reactor core. Reflected reactors (elementary treatment). Reactor kinetics, control and instrumentation. Applications of heat transfer, fluid flow and stress analysis to the reactor core. The measurement and control of radiation. Exposure of humans to radiation. Shielding techniques. Nuclear engineering applications of nuclear and radio-chemistry. Experiments are carried out with radiation sources and instruments, a subcritical reactor, a reactor simulator, pulse height analyzers, fast neutron generators and radioactive tracers.

D. G. Andrews, J. S. Hewitt

CHE 443 ORGANIC CHEMISTRY

Elective 2 3 – 8, 2 3 – 8

A comprehensive, elementary, organic chemistry course available to students in any year other than those enrolled in Program 6, intending to qualify for entrance into the Faculty of Medicine. Lectures and laboratories are scheduled at times convenient to those registered. The lectures cover the simple hydrocarbons, their halogen and oxygenated derivatives, amino derivatives, and other derivatives of importance to biological systems, all with emphasis on structure and functionality. The major part of the course is spent on amino acids, sugars, and fatty esters with emphasis on natural and synthetic polymers of biological interest or use. The concurrent laboratory emphasizes typical laboratory reactions of these classes of materials.

H. L. Williams

CHE 499 THESIS AND PUBLIC DISSERTATION

IV – 6 – 10 – 10, – 18 2 22

The thesis will be graded after submission in the spring term and the grade included in the weighted average for that term only. The weight assignment will be the sum of the weights for both terms.

Senior Staff in Chemical Engineering

CIVIL ENGINEERING

CIV 100F APPLIED MECHANICS

I – 1, 3, 4, 6, 7, 8, 9 3 – 2 10

Statics: The principles of statics are applied to the composition and resolution of forces, moments and couples. The equilibrium states of frames and machines are examined. The distributed load concept is applied to finding centroids, centers of mass and fluid pressure. Dynamics: Applications of the principles of dynamics are discussed for motion on straight and curved paths. Work, energy, power and momentum concepts are applied to particles, systems of particles and rigid bodies. Simpler applications in relative motion are considered. Throughout statics and dynamics the free body concept is emphasized and vector algebra is used where it is most useful.

G. T. Will and Staff in Civil & Mechanical Engineering

CIV 101F MECHANICS (STATICS)

I– 5 2 – 1 6

Translational and rotational resultants and equilibrants are discussed together with equivalent force systems in two- and three-dimensional space. Emphasis is placed on systems in equilibrium. Distributed forces, applications to structures, friction, method of virtual work, potential energy and stability of equilibrium are considered.

S. M. Uzumeri, M. P. Collins

CIV 135F & S ENGINEERING GRAPHICS

I – 1, 3, 4, 6, 7, 8, 9 2 5 – 8

A course to provide an introduction to graphical communication in contemporary engineering practice. Topics in descriptive geometry and engineering drawing include orthographic projection, single view drawings, spatial analysis, developments and intersections, sketching, preparation of graphs and nomographs and the reproduction of drawings.

C. A. Wrenshall and Staff in Civil Engineering

CIV 136S ENGINEERING GRAPHICS

I – 5 (elective) 2 – 2½ 8

A course on the use of graphical theories and methods as a means of visual communication in the development of engineering concepts. The lectures and laboratory problems deal with the ideas, problem refinement, solution analysis and solution implementation.

R. D. Foster

CIV 203S MECHANICS OF MATERIALS

II – 5 (elective) 2 – 3 8

Structural design philosophy and methods; structural properties of engineering materials; basic relationships between force and deformation of deformable bodies; behaviour of structural components subjected to tension, compression, bending and torsion; design of structures such as pressure vessels, towers and machine elements.

M. P. Collins

CIV 204F MECHANICS OF MATERIALS

II – 8 3 1½ – 8

The fundamental relations among stress, strain and applied load are worked out for tension, compression, twisting and bending in the elastic and inelastic ranges, for various engineering materials. The buckling of struts and columns is examined. Laboratory: An experimental study of engineering materials and structural members under various loading conditions. (Prerequisite CIV 100F)

A. C. Davidson

CIV 205S MECHANICS OF MATERIALS

II – 4 (elective) 2 3 – 8

An introduction to the elastic behaviour of solids under various load conditions. The basic concepts of strength and stiffness are examined and their application to the design of elementary structural systems considered. Laboratory: An experimental study of engineering materials and structural members under load. (Prerequisite CIV 100F)

J. D. Barber

CIV 209S ENGINEERING MATERIALS

II – 1, 9c 4 2 1 10

Deals with the basic principles necessary for the undertaking and selection of materials used in Civil Engineering and points out the significance of these in practice. Fundamentals which provide a common basis for the properties of various materials are stressed.

One third of the laboratory time is devoted to demonstrations illustrating the fundamentals covered in the lectures, the remaining time to project work in small groups. (Prerequisite CIV 210F)

J. Timusk and Staff in Materials Science

CIV 210F STRENGTH OF MATERIALS

II – 1, 9c; 9a, 9b (elective)

3 – – 8

An introduction to the elastic and inelastic behaviour of solids under various load conditions. Stress, strain, and deformation relations are determined for members subjected to tension, compression, torsion and bending forces. (Prerequisite CIV 100F)

J. D. Barber

CIV 211S MECHANICS AND DESIGN OF STRUCTURES

II – 1

4 – 2 10

This course is primarily an introduction to structural design and topics examined include basic concepts, types of structures, loads, safety factors, specifications and common failure modes. The design of structural components in steel, concrete and timber using the National Building Code is investigated.

Topics to be covered in engineering mechanics include virtual work, energy methods in structural analysis and an introduction to vibration. (Prerequisite CIV 210F)

S. M. Uzumeri

CIV 240S ENVIRONMENTAL SYSTEMS

II – 1, 9c

2 – – 5

Growth and distribution of population; the trend to urbia; cycles of life, energy and materials in nature; biological hazards of pollution. Air pollution: damages, economy, control possibilities. Water pollution: purification and distribution of water, collection and treatment of waste water. Soil pollution: refuse disposal, home disposal of sewage.

A. P. Bernhart

CIV 255F SURVEYING

II – 1; II – 9, III – 9c (elective)

3 2 1 9

General principles and practice of surveying including: measurement of horizontal distances, horizontal angles, vertical distances. Survey calculations, sources of errors, corrections and adjustments. Route surveying, construction surveying and introduction to airphoto interpretation and photogrammetry.

B. J. Haynes and Staff in Civil Engineering

CIV 260F COMPUTER PROGRAMMING

II – 1

2 – 2 8

This course continues the study of programming requirements and techniques introduced in course APS 100F-S; the full standard FORTRAN language is used; emphasis is placed on subprogram philosophy and organization, and on flow charts and program documentation. Engineering problem oriented languages such as ICES-COGO and ICES-STRUDL are introduced and used. A few operations at machine language level are examined and illustrated on an emulated simple computer. Some experience is provided in the use of a time-shared interactive computing system. (Prerequisite APS 100F/S)

R. A. Collins

CIV 267F THE ENGINEER AND HIS ENVIRONMENT

II – 1, 9c; 9a, 9b (elective) 2 2 2 8

An introduction to the role of the engineer in the solution of society's problems. Lectures, seminars and discussion periods by staff of all areas of Civil Engineering and guest speakers. Projects on qualitative solutions to engineering problems. Instruction and practice in presentation of technical data and reports.

Staff in Civil Engineering

CIV 268S THE CIVIL ENGINEER AND HIS PROFESSION

II – 1 2 2 2 8

An introduction to the different facets of Civil Engineering. Lectures, seminars and discussion periods by staff of all areas of Civil Engineering and guest speakers. Group projects on qualitative solutions to comprehensive engineering problems.

Staff in Civil Engineering

CIV 312F DESIGN OF STRUCTURES II

III – 1 3 – 2 9

A course on the design of structures with emphasis on the design and analysis of determinate systems including influence lines for beams and trusses. Detailing and fabrication aspects of such structures in steel and in reinforced concrete are examined. (Prerequisite CIV 211S)

CIV 313S DESIGN OF STRUCTURES III

III – 1 3 – 2 10

A course on the design of structures with emphasis on indeterminate systems. Topics considered include the analysis of indeterminate structures by moment distribution and by approximate methods, design of reinforced concrete footings, retaining walls and continuous slabs, introduction to prestressed concrete. (Prerequisite CIV 312F)

CIV 321F SOIL MECHANICS

III – 1, 9c; III – 9a, 9b; IV – 9 (elective) 2 1 – 6

Identification and classification of soils for engineering purposes; properties, permeability and drainage characteristics, effective stresses, consolidation and settlement, shearing strength, compaction, stabilization, frost action. Laboratory sessions include identification of soil samples and determination of mechanical properties of soil.

E. I. Robinsky

CIV 322S FOUNDATIONS

III – 1, 9c; 9a (elective) 2 1 1 7

Site investigations and sampling, response of soil to load, lateral earth pressure, retaining walls, braced cuts, anchored bulkheads, bearing capacity, shallow foundations, settlement, deep foundations, slop stability. Laboratory sessions are devoted to design problems. (Prerequisite CIV 211S, CIV 321F)

F. A. DeLory

CIV 327S PLEISTOCENE GEOLOGY

III – 9c; 9a (elective) 3 2 – 8

The causes, extent, and effects of Pleistocene ice caps, especially in North America. Origin and classification of land-forms of glacial origin. Methods of dating and analyzing these deposits. Periglacial phenomena, including permafrost. The extent of and the economic and engineering significance of glacial deposits in North America.

CIV 328F MINING TECHNOLOGY I

III – 9b; 9a, 9c (elective) 3 – 1 8

An introduction to mining practice, and its basic unit operations and processes; including drilling and blasting, acquisition of mineral lands. Sampling theory and practice provide background for future evaluation problems.

H. R. Rice

CIV 329S MINING TECHNOLOGY II

III – 9b; 9a, 9c (elective) 2 – 2 8

Mine layouts and principal mining methods as applied to geological situations and stress environments. Further study of cost-making factors, including transportation, mine hoisting. Introduction to mine-smelter relationships, and other economic aspects. (Prerequisite CIV 328F)

H. R. Rice

CIV 330S TRANSPORTATION SYSTEMS

III – 1 3 – 2 8

A brief history of Canadian transportation development and a discussion of current policy, regulation and administration structure introduces a comparative study of transportation modes including their cost characteristics. The principles of location, flows on networks and the concepts of capacity and control are studied. The transportation planning process is introduced with emphasis on analytical techniques.

G. N. Steuart

CIV 340S MUNICIPAL ENGINEERING

III – 1 2 – 2 7

Quantities of water and waste water; hydrologic cycle, analysis of hydrologic data, applications of hydrology to engineering design; waste water collection systems, water distribution systems, refuse disposal, administration and financing of municipal works. Laboratory: Design problems supplementing lecture material. (Prerequisite MEC 351F, corequisite CIV 240S)

G. W. Heinke, G. K. Rodgers

CIV 358F SURVEY CAMP

III – 1 ----

At Survey Camp, students obtain further experience in the use of instruments and in the essentials of survey practice. Emphasis is placed on adjustments of levels and transits, route surveys, higher order surveys, topographic surveys, practical astronomy and photo interpretation. Students entering Third Year Civil Engineering will be required to take the Survey Camp from August 21 to September 5, 1972.

The camp is held at Dorset and Gull Lake with students in attendance paying for the cost of their accommodation.

Applications to defer attendance or for exemption from the camp must be made to the secretary of the Faculty before July 15, 1972. (Prerequisite CIV 255F)

B. J. Haynes and Staff in Civil Engineering

CIV 359F SURVEY CAMP

III – 9a, 9c (optional) ----

At Survey Camp, students obtain experience in the use of instruments and in the essentials of survey practice. Emphasis is placed on topographic surveying and mapping, underground surveying including shaft plumbing and the use of mine surveying instruments, route surveys, curve layout, earthwork quantity computations, astronomic observations for time azimuth.

The camp will be held at Gull Lake, from August 23 to September 5, 1972. Students attending the camp pay for the cost of their accommodation.

B. J. Haynes and Staff in Civil Enginering

CIV 370F ENGINEERING MATHEMATICS

III – 1 3 – 2 8

Numerical integration, solution of ordinary and simple partial differential equations by numerical procedures, solution of linear algebraic equations, mathematical programming, analogue computer. (Prerequisite MAT 280F)

G. T. Will

CIV 371F PROBABILITY AND STATISTICS

III – 1 2 – 2 7

Topics to be considered include definition of probability, binomial, poisson and normal distributions, frequency and sampling distribution. Examples of estimation, hypothesis testing, introduction to experimental design and regression theory.

CIV 375S ENGINEERING ECONOMICS AND DECISION MAKING

III – 1, IV – 1 (elective) 3 – 2 8

Design as selection between alternatives. Economic efficiency and other goals. The objective function and the use of optimization techniques. Time scale of consequences and its reduction. Interest rate and social rate of return. Market and non-Market valuation. Economic life, replacement and salvage value. Treatment of risk and uncertainty. Public investment. Financing.

E. Hauer

CIV 405F ADVANCED STRENGTH OF MATERIALS

IV – 1 (elective) 3 – 2 8

The following topics are introduced or extended beyond their elementary treatment: elastic buckling of axially loaded bars, torsion of bars having non-circular cross sections; unsymmetrical bending of beams; beams on elastic foundations; curved beams; beam-columns; rings; elementary theory of elasticity; elementary plate theory. (Prerequisite CIV 370F)

R. A. Collins

CIV 414S ADVANCED ENGINEERING MATERIALS

III – 1, IV – 1 (elective) 3 – 2 8

A seminar and laboratory course with emphasis on project work at an advanced level in the areas of: properties and analysis of requirements in construction materials; response of materials to service requirements; selection and specification of materials. Materials to be considered include metals, concrete, wood products, polymers and composites. (Prerequisite CIV 209S)

CIV 416F REINFORCED CONCRETE I

IV – 1 (elective) 3 – 2 8

This course covers the behaviour and ultimate strength of reinforced concrete structures. Members subjected to flexure, axial load, shear and torsion are treated. Detailing of reinforcement, the design of floor systems and the design of shear walls are covered. Emphasis is given to the relationship between recent research results and current building codes. (Prerequisite CIV 313S)

M. P. Collins

CIV 417S REINFORCED CONCRETE II

IV – 1 (elective) 3 – 2 8

Prestressed Concrete – tension members, simple span and continuous span flexural members, columns and torsion resisting members. Slender reinforced columns. Yield line methods for slab analysis and design. (Prerequisite CIV 416F)

M. W. Huggins

CIV 418S BEHAVIOUR AND DESIGN OF STEEL STRUCTURES

IV – 1 (elective) 3 – 2 8

The behaviour of structural elements and structures and their connection by welding and bolting are examined and related to design methods and criteria. Topics to be considered include repeated loading, brittle fracture, elastic-inelastic behaviour, buckling and ultimate capacity. (Prerequisite CIV 313S)

D. E. Thomson

CIV 419F INDETERMINATE STRUCTURES

IV – 1 (elective) 3 – 2 8

Internal forces, support reactions, structural displacements and influence lines are computed for continuous beams, arches, closed rings, frames, trusses, Vierendeel trusses and grids. Slope-deflection, moment distribution, Kanis, Flexibility and stiffness methods, virtual work and Muller-Breslau principles, and Maxwell's law of reciprocal displacements are studied. An introduction to structural analysis by matrix organization is examined. (Prerequisite CIV 313S)

E. Karuks

CIV 420S CONSTRUCTION ENGINEERING

IV – 1, 9 (elective) 3 – 2 8

This course deals with business and management aspects of construction – construction company organization, construction tenders and contracts, the elements of a construction project, project management, planning and scheduling, job administration, field engineering; and construction methods and equipment. A number of construction sites and construction material manufacturing plants are visited during the scheduled laboratory periods.

K. A. Selby and Staff in Civil Engineering

CIV 421F FOUNDATIONS AND EARTHWORK

IV – 1 (elective) 3 – 2 8

Design and construction of: foundations for buildings, bridges and other structures including excavation, footings, piling, caissons; retaining walls, sheet pile bulkheads; fills, embankments, earth-fill and rock-fill dams including seepage, dewatering and grouting. The laboratory sessions include design problems and studies of case histories. (Prerequisite CIV 322S)

E. I. Robinsky

CIV 422S ENGINEERING GEOLOGY

III – 1, IV – 1 (elective) 3 – 2 8

The study of engineering practice from a geological point of view. The behaviour of rocks and soils in building and engineering construction, foundations, tunnels, dams, and flood-control works with reference to the importance of the mineral composition of earth and rock materials, their geomorphic and geologic features and their stress history. Engineering case studies will include examination of groundwater, frost and landslide conditions, shoreline engineering, construction in permafrost, earthquake problems, and field investigations (Prerequisite GLG 280S)

F. A. DeLory

CIV 426F MINE OPERATION AND ADMINISTRATION

IV – 9 (elective) 2 – 3 8

Operational, financial, legal, and economic considerations in the valuation and management of mineral enterprise. Laboratory work is given on a progressive problem in the estimation of grade and tonnage in an ore situation. While CIV 328F is not a prerequisite, a knowledge of its content would be useful.

H. R. Rice

CIV 427S MINE OPERATION AND ADMINISTRATION II

IV – 9 (elective) 2 – 3 8

A continuation of the subject matter of CIV 426F. In the laboratory the problem evaluated in CIV 426F is pursued through the selection of optimum mining rate and the design of enterprise, complete to the point of financing. (Prerequisite CIV 426F)

H. R. Rice

CIV 429F AIR PHOTO INTERPRETATION

III – 9a, 9c; IV – 1, 9 (elective) 3 2 – 8

The principles of interpretation of aerial photographs; processes of formation and erosion of landforms, both unconsolidated and consolidated, with particular emphasis on glaciation, their patterns as seen on aerial photographs, their identification and evaluation, and the engineering problems involved; location of granular materials; soil mapping; investigations from airphotos for highway, powerline, and pipeline locations, damsites and flood control structures; delineation of drainage areas and drainage structure location; classification of muskeg areas and prediction of depth, land use classification. One day field trip, including field soil testing.

CIV 430F TRAFFIC ENGINEERING

IV – 1 (elective) 3 – 2 8

Introduction to the basic principles and methods of Traffic Engineering. Driver, vehicle and roadway characteristics. Description and measurement of traffic streams. Micro and macroscopic properties. Highway intersection capacity. Traffic accidents, their relation to design and their control. Traffic signing and signalization. Area traffic control and surveillance. Illumination. Parking. Reference Book: *Traffic Engineering* and *Handbook*. (Prerequisite CIV 330S)

E. Hauer

CIV 431F TRANSPORTATION PLANNING

IV – 1 (elective) 3 – 2 8

This course deals with the transportation planning process, with emphasis on urban and regional applications. Surveys and data collection, mathematical models and transportation demand analysis, transit and highway system alternatives, methods of project and systems evaluation. Reference Book: *Principles and Techniques of Predicting Future Demand for Urban Area Transportation*, Martin, Memmott and Bone, M.I.T. Press. (Prerequisite CIV 330S)

R. G. Rice

CIV 432S HIGHWAY ENGINEERING

IV – 1, 9 (elective) 3 – 2 8

A basic course in which the following topics are examined: highway systems and geometric design; highway materials and their behaviour; and pavement systems. The laboratory part of the course is mainly devoted to a design project.

M. M. Davis

CIV 440F POLLUTION CONTROL ENGINEERING

IV – 1, 9 (elective) 3 – 2 8

Control of air, water and soil pollution. Air pollution: effect on man's environment, types of air pollution, influence of man, his planning and available equipment to control exhaust gases. Water pollution: quantities and qualities, purification of water, treatment of municipal and industrial waste water, self-purification of rivers. Soil pollution: depositing solid wastes, infiltration of treated waste water into soil. (Prerequisite CIV 340S)

A. P. Bernhart, K. Reichert

CIV 450F WATER RESOURCES AND HYDROLOGY

IV – 1 (elective) 3 2 9

The availability and management of water for optimal use in the broadest sense. Qualitative and quantitative evaluation of surface and ground water sources. Rainfall, run-off and stream-flow analysis. Storage, flood control, diversion and related hydraulic structures. Uses of water and forecasting the demand. Quality standards, ecological, economic, sociological, legal and political factors affecting water management. Benefit/cost analysis. (Prerequisite CIV 340S)

A. C. R. Albery

CIV 455F PHOTOGRAMMETRY AND REMOTE SENSING

IV – 1, 9 (elective) 3 2 – 8

Camera as a measuring instrument. Construction, viewing and measuring of stereoscopic models. Applications in engineering, forestry, architecture, geography, etc. Remote sensing and the electromagnetic spectrum. Spectral characteristics of natural objects. Examples of remote sensing in natural resource studies.

J. Vlcek

CIV 456S ENGINEERING APPLICATIONS OF SURVEYING

III – 1, IV – 1 (elective) 3 – 2 8

Theory, methods and instrumentation of engineering surveys. Special applications in

Civil Engineering structures such as: bridges, dams, tunnels, highways, airports, power lines, and pipelines. Introduction to hydrographic surveying. Engineering applications of and introduction to legal surveying as related to engineering projects. (Prerequisite CIV 358F)

B. J. Haynes

CIV 457S GEODETIC CONTROL SURVEYS

IV – 1 (elective) 3 – 2 8

Design and statistical analysis of survey control for engineering and photogrammetric projects.

The detection of structural deformations and earth movement by means of surveying and photogrammetry. Also included is a study of the national and urban control systems and their use in engineering projects. This course is complementary to course CIV 456S. (Prerequisite CIV 358F)

R. C. Gunn

CIV 474S PUBLIC SPEAKING

IV – 1 – – 2 3

A subject emphasizing student participation and designed to develop facility in oral presentation before groups. Beginning with short talks, students move on to longer prepared talks on technical subjects. Experience and observation are also offered in the conduct of meetings.

H. R. Rice, A. C. Davidson, J. D. Barber

CIV 475F ADMINISTRATION AND MANAGEMENT

IV – 1 2 – – 6

An introduction to the various management functions involved in operating a business; including planning, organizing, staffing, directing, controlling and labour relations. Individual proprietorships, partnerships and limited company operations are discussed.

K. A. Selby, H. L. Macklin

CIV 479F & S SPECIAL STUDIES IN CIVIL ENGINEERING

IV – 1 (elective) 3 – 2 8

Students having the Departmental Chairman's approval, may undertake special studies of advanced topics that are not normally part of the undergraduate program.

CIV 498F THESIS

IV – 1 (elective) – 4 – 8

With the approval of the Departmental Chairman, a Fourth Year student in Civil Engineering may undertake a 21-unit thesis instead of the usual 12-unit thesis (CIV 499S). Normally such theses will be experimental in nature and the topic must be submitted prior to the commencement of the fall term.

CIV 499S THESIS

IV – 1 – 6 – 12

All students in the Fourth Year of the Civil Engineering program must prepare a thesis on an approved subject. Topics are normally submitted for approval in the fall term with the work being done in the spring term under the supervision of a faculty member.

COMMERCE
(Department of Political Economy)

COM 390F ACCOUNTING I

III – 4 2 – 1 8

Accounting methods and principles; build-up of financial statements.

R. Peretz

COM 391S ACCOUNTING II

III – 4 2 – 1 8

Analysis and interpretation of financial statements; introduction to cost accounting and managerial accounting. (Prerequisite COM 390F)

R. Peretz

DEPARTMENT OF COMPUTER SCIENCE

CSC 180F INTRODUCTION TO COMPUTER PROGRAMMING

I – 5 1 3 – 5

Introduction to algorithms and computer organization; PL/I programming; numerical and non-numerical applications; simulation.

R. C. Holt, D. B. Wortman

CSC 236S NUMERICAL METHODS

III – 8, 9b 2 – 2 7

Solution of non-linear equations, approximation, quadrature, solution of systems of linear equations, eigenvalues and eigenvectors, differential equations. Exercises requiring the use of a computer will be assigned.

N. A. Derzko

CSC 280S COMPUTER LANGUAGES

II – 5 2 – – 8

Definition of various programming languages including procedure-oriented, list processing, and simulation languages. Specification of syntax and semantics. Basic properties of programming languages. Introduction to formal languages and data structures.

J. N. P. Hume

CSC 281F NUMERICAL METHODS

II – 5 2 – 1 7

Roots of equations, interpolation, quadrature, numerical solution of ordinary differential equations, matrix calculations, eigenvalues, roundoff errors.

J. C. Mason

CSC 380S SYSTEM SOFTWARE I

III – 5cs 2 6 – 10

Data structures as applied to assemblers and macroassemblers. Recognition of simple grammars. Input/output systems – data handling techniques as related to system hardware organization. The laboratory associated with this course will include assembly language programming.

E. S. Lee

CSC 381F NUMERICAL METHODS I

III – 4 2 – 2 8

Roots of equations, interpolation, approximation theory, quadrature, numerical solution of ordinary differential equations. (Prerequisite MAT 294S)

CSC 386S NUMERICAL METHODS II

III – 4 2 – 2 8

Matrix calculations, eigenvalues, roundoff errors, random numbers, extrema of functions of several variables. (Prerequisite CSC 381F)

E. V. Swenson

CSC 390S INTRODUCTION TO THE THEORY OF COMPUTATION

III – 5cs 2 – – 7

Introduction to formal logic—propositional and predicate calculus. Primitive recursive functions, computable functions, recursive functions, and recursive sets. Turing machines, unsolvable problems. Models, flow-charts, and program schemata; application to equivalence, termination, and correctness of programs.

J. Mylopoulos

CSC 446S COMPUTIONAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS

IV – 5cs 2 – 1 8

Initial value problems for partial differential equations. Consistency, convergence, stability. Boundary value problems. Mixed initial-boundary value problems. Difference schemes for nonlinear problems.

CSC 468F OPERATING SYSTEMS

IV – 5cs 2 – 1 8

Computational structures. Processes and their cooperation; operating systems functions and facilities. Processor allocation; memory management; input-output and files; resource sharing. Correctness and reliability; protection and security. Design methodology; implementation; measurement and evaluation.

D. Tsichritzis

CSC 480F SYSTEM SOFTWARE II

IV – 5cs 2 – 6 10

Compiler construction for high level languages; scanning techniques, symbol table techniques, table driven techniques, expression decoders, translator writing system techniques. System services with emphasis on their relation to computer system architecture. The laboratory associated with this course will consist of programming projects in IBM/360 assembly language as well as various high level languages.

J. J. Horning

CSC 481F NUMERICAL METHODS

IV – 3 2 – 2 8

Roots of equations, interpolation, quadrature, numerical solution of ordinary differential equations, matrix calculations, eigenvalues, roundoff errors.

J. C. Mason

ELECTRICAL ENGINEERING

ELE 121S ELECTRICITY AND MAGNETISM

I – 1, 3, 4, 6, 7, 8, 9 3 1 1 10

A basic course in electricity and magnetism including electric forces and fields, analysis of direct-current circuits, magnetic forces and fields, electromagnetic induction, and an introduction to the conductive, magnetic and dielectric properties of materials.

ELE 150S ELECTRICITY AND MAGNETISM

I – 5 3 – – 8

An introduction to electricity and magnetism adapted to the needs of Program 5. Elements of vector calculus. Coulomb's Law. Gauss's Law. Electric field of discrete and continuous charge distributions. Potential functions. Gradient and divergence. Laplace's equation. Method of images. Forces and energy. Capacitance. Forces on moving charges and conductors. Ampere's Law. Biot-Savart Law. Magnetic field of rings and coils. Faraday's Law and applications. Self- and mutual-inductance. Energy stored in a magnetic field. Alternating current circuits: series and parallel. Electric and magnetic fields in matter.

ELE 200F COMPLEX VARIABLES AND VECTOR CALCULUS

II – 7 3 – 2 8

Functions of more than one variable, partial derivatives, multiple integrals, maxima, minima, area and volume. Differentiation and integration of vector functions, gradient, curl, divergence, Gauss' and Stokes' theorem. Calculus of functions of a complex variable, Cauchy Riemann equation, residues and Cauchy integral theorem, applications to mapping and contour integration. Text to be announced. (Prerequisite MAT 181S; Corequisite MAT 291F)

ELE 201S NUMERICAL AND PROBABILISTIC METHODS

II – 7 3 – 2 8

Errors in computation. Elementary numerical methods for non-linear equations, zeros of polynomials, systems of linear algebraic equations, characteristic values, interpolation, curve and surface fitting, vector least squares, integration, ordinary differential equations and systems of differential equations. Probability. Conditional and joint probability, Bayes theorem. Distributions of random variables, continuous and discrete. Uniform, exponential, binomial, Poisson distributions. Functions of a random variable. Mean, variance, moments. Sampling theory. Confidence limits and hypothesis testing. Pseudo-random numbers. Monte Carlo simulation. Text to be announced. (Prerequisite MAT 291F)

ELE 210F CIRCUIT THEORY I

II – 7 3 1½ 1 9

Circuits as models for physical devices; relationships between circuit and field concepts. Elementary network theorems and laws. Transient response of circuits. Topology and loop and nodal analysis. Duality. Response to complex frequency excitation. General solution of linear differential equations with constant coefficients. Steady-state response with direct and sinusoidal sources including analysis of polyphase circuits. The laboratory provides an introduction to techniques of electrical measurement. Text: Close "The Analysis of Linear Circuits". (Prerequisite ELE 121S. Corequisite MAT 291F)

ELE 211S CIRCUIT THEORY II

II – 7 3 1½ 1 9

Complex frequency, network functions, poles and zeros, frequency response, the S plane. Resonance phenomena. Magnetically coupled circuits. Impedance transformations. Two-port networks. General network theorems. Transfer functions. Orthogonal functions and the Fourier series and transform. Laplace transforms. Linear systems. Pole zero plots. Texts: Close "The Analysis of Linear Circuits"; Lathi "Signals, Systems and Communications". (Prerequisites ELE 210F, ELE 200F)

ELE 221S ELECTRIC AND MAGNETIC FIELDS

II – 7 3 – 2 8

Static electric and magnetic fields. Properties of dielectric and magnetic media. Particle dynamics in electric and magnetic fields. Time-varying fields. Development of Maxwell's equations and interpretation. Text: Hoyt "Engineering Electromagnetics". (Prerequisites: ELE 200F, ELE 210F, MAT 291F)

ELE 231S ELECTRONICS I

II – 7 2 1½ 1 8

A global view of electronics and electronic systems considering the following topics: The ideal diode. Vacuum tubes, semiconductors, PN junctions. Bipolar transistors. DC amplifiers. Large signal switching. Text: Angelo "Electronics: BJT's, FET's, and Microcircuits". (Prerequisites ELE 210F, MMS 221F. Corequisite ELE 211S)

ELE 250F ELECTRIC CIRCUITS

II –5 3 3 – 8½

The linear electric network as a model. Signal waveforms and specifications. Models of network components. Kirchhoff's laws. Energy and power. Network equivalents. Steady-state sinusoidal analysis. Impedances and network functions. Three-phase networks. Resonance and signal filtering. Network equations and their solutions. Two-ports. Transient response of circuits. Impulse response and convolutions. Harmonics, Fourier analysis. Laplace Transforms. State variable techniques.

ELE 270F CIRCUIT THEORY AND MEASUREMENTS

II – 3 3 1½ 1½ 10

Introduction to linear circuits analyses. Phasor representation and the analysis of alternating current circuits in the steady state. Transducers for electical measurement of non-electrical variables, and associated instrumentation.

ELE 271S ELECTRICAL ENGINEERING

II – 4 (elective) 3 1½ 1 8

Analysis of single-phase and three-phase circuits; principles of ac and dc machines; introduction to vacuum-tube and solid-state devices; basis of digital computation and analogue simulation; electronic measurements applied to industrial processes.

ELE 272S ELECTROMECHANICAL ENERGY CONVERSION

II – 3 3 1½ 1½ 8

Principles of electromechanical energy conversion. Electromechanical systems. Actuators. Transient and steady-state operation of dc machines. Steady-state operation of ac machines.

ELE 300F APPLIED MATHEMATICS I

III – 7 (1972–73 only) 2 – 1 6

Theory of functions of complex variables, with applications. Partial differential equations. Text: Churchill "Complex Variables and Applications". (Prerequisite ELE 221S)

ELE 310F SYSTEM AND SIGNAL ANALYSIS I

III – 7 3 – 1 7

System representation and analysis. State variable formulation. Review of Fourier series, Fourier transform, and Laplace transform. A study of the behaviour of continuous-time linear systems using transform methods. Transfer functions, frequency response, Bode diagrams, energy density spectrum. Stability, Routh-Huriwitz, Nyquist, root locus. Signal flow graphs. Texts: Lathi "Signals, Systems and Communication"; Dorf "Modern Control Systems". (Prerequisite ELE 211S)

ELE 311S SYSTEM AND SIGNAL ANALYSIS II

III – 7 3 1½ 1 9

Convolution integral and methods. Communication systems, multiplexing, modulation, and sampling. Stochastic processes, stationarity, convolution, correlation, power spectrum, spectral analysis. Texts: Lathi "Signals, Systems and Communication"; Davenport "Probability and Random Processes". (Prerequisite ELE 310F)

ELE 312F ELECTROMECHANICAL SYSTEMS I

III – 7 2 1½ 1 8

Review of Maxwell's equations, energy, force, conservation of energy. Magnetic circuit analysis, linear and non-linear. Ideal transformer and transformer design. Single phase and three phase transformers. Electromechanical energy conversion principles. Rotating machines and their construction. Texts: Slemon "Magneto-Electric Devices"; Fitzgerald, Kingsley, Kusko "Electric Machinery, 3rd ed." (Prerequisites ELE 211S, MEC 205F. Corequisite ELE 311S)

ELE 313S ELECTROMECHANICAL SYSTEMS II

III – 7 3 1½ 1 9

Generalized machine parameter evaluation, reduction. Steady-state and dynamic performance of DC, induction and synchronous machines. Introduction to multi-machine systems. Texts: Slemon "Magneto-Electric Devices"; Fitzgerald, Kingsley, Kusko "Electric Machines". (Prerequisite ELE 312F)

ELE 314S DIGITAL SYSTEMS

III – 7; III – 5e (elective) 2 ¾ – 6

Introduction to logic, propositional logic, Boolean algebra, basic operations, truth tables, fundamental algebraic manipulations. Storage elements, flip-flops and registers, register transfer operations. Counters, encoders, decoders. Fan-in, fan-out. Number representation and coding, 1's and 2's complement, BCD, parity. Adders, multipliers, dividers. Memory techniques, read/write, read only, volatile, non-volatile magnetic core memory. Control and data flow in simple systems. Sampled data communications, feedback digital controller, application to power systems. Text: T. L. Booth "Digital Networks and Computer Systems". (Prerequisites ELE 201S, ELE 231S or equivalent)

ELE 320F FIELDS AND WAVES

III – 7 2 1½ 1 8

Propagation of plane waves. Reflection of waves at plane boundaries. Guided waves. Transmission line theory. Smith chart. Radiation from antennas. Diffraction and scattering. Introduction to holography. Text: Skilling "Fundamentals of Electric Waves". (Prerequisite ELE 221S)

ELE 331S ELECTRONICS II

III – 7 3 3 – 10

P-N Junction diode models: advanced applications of p-n junction diodes. Temperature dependence of diode characteristics and methods for compensation. JFET's and MOSFET's, characteristics, biasing, models, circuits. Bipolar transistors, basic concepts, fabrication, power gain, basic configurations, Ebers and Moll model, circuit models, single and multistage amplifiers. Feedback amplifiers, oscillators. Narrow and wide band amplifiers. Introduction to switching circuits. Text: Angelo "Electronics: BJT's, FET's, and Microcircuits". (Prerequisite ELE 231S. Corequisite ELE 336S)

ELE 335F PHYSICAL ELECTRONICS A

III – 7; III – 8 (elective) 2 – ½ – 6

Quasi-Free electron theory of solids. Electron emission. Structure and basic properties of semiconductors. Carrier transport. P-N junction diode, tunnel diode, Schottky diode, Gunn diode. Text: Perry and Fanin "Physical Electronics". (Prerequisites MMS 221F, ELE 201S)

ELE 336S PHYSICAL ELECTRONICS B

III – 7 2 – 1½ 6

Unipolar transistors: basic types: junction-gate, M.I.S., and thin-film F.E.T.'s theory, circuit models. Bipolar transistors: fundamental theory, injection efficiency, base transport efficiency, small-signal low-frequency models. Charge storage models. High-frequency, small-signal analysis and circuit models. Fundamentals of integrated circuits: fabrication theory and technology: diffusion, epitaxy, oxide masking; capacitors, resistors, bipolar and unipolar transistor integration. Examples. Photoelectronics solid-state optoelectronic phenomena: photoconductive, photovoltaic and pn junction radiation detection. Vacuum photoelectronics: image orthicon, vidicon, image storage and intensification. Text: Perry and Fanin "Physical Electronics". (Prerequisite ELE 335F)

ELE 350F PHYSICAL ELECTRONICS I

III – 5cs, 5e, 5p, 8 (elective) 2 1½ – 7

Courses 350F and 352S deal with the basic physics underlying the operation of semiconductor devices. Band theory of solids, metals, semiconductors, insulators, mobility and conductivity. Drift and diffusion currents. Theory of pn junctions. Tunnel and avalanche diodes. Bipolar transistors.

ELE 351F INTRODUCTORY ELECTRONICS

III – 5cs, 5e, 5p (elective) 2 1½ – 8

A communication system, an analog computer and a digital computer, as examples of electronic systems. Identification of basic circuit functions. Passive RLC circuits as load and coupling circuits in both the time domain and the frequency domain. Ideal active elements: Amplifiers, operational amplifiers, controlled sources, logic elements and memory elements. Nonideal behaviour of amplifiers and their classification. Ideal and real diodes and other applications. Qualitative description of pn junctions. Characteristics of bipolar transistors in the normal mode. Biasing of single transistor circuits. Derivation of 1st order equivalent circuits. Simple one transistor amplifier circuits.

ELE 352S PHYSICAL ELECTRONICS II

III – 5e, 5p (elective) 2 1½ – 7

Recombination-generation processes. Further properties of the bipolar transistor. Junction field effect transistors; MOS transistors. Fundamentals of integrated circuits. Photoconductivity. Solid state optoelectronic phenomena. Vacuum photoelectronics: image orthicon, vidicon.

ELE 353F COMPUTER ORGANIZATION

III – 5cs, IV – 5e (elective) 3 1½ 1 10

Digital system principles. Registers and data flow. Computer structure, machine language instruction execution and sequencing, addressing techniques. Digital representation of data. Arithmetic operations. Memory hierarchy, direct and associative addressing. I/O techniques and channels. Some case studies of actual machines. Introduction to reliability.

The laboratory will include simulation studies of systems using GPSS, experiments involving logic systems and small computers, and problems.

ELE 354S ELECTRONICS II

III – 5e 3 3 – 10

AC coupled transistor stages. DC amplifiers. Integrated circuit design limitation. Multitransistor circuits from configuration point of view. Hybrid Π equivalent circuit models. Audio amplifiers. Wideband amplifiers. Tuned amplifiers. Negative feedback concepts and oscillators. Field effect devices and applications. Transistors as switching elements, simple logic and memory circuits.

ELE 355F SYSTEM AND SIGNAL ANALYSIS I

III – 5e, IV – 5cs 3 – 1 8

Vector spaces. Normed linear vector spaces. Projection theorem. Approximation theory. Representation of signals by orthogonal functions; Fourier series, integral and transform. Modulation. Laplace transform. Z-transform. Block diagram manipulation. Study of the behaviour of continuous-time and discrete linear systems using transform and convolution methods. Applications. (Prerequisite ELE 250S or ELE 211S with good standing)

ELE 356S SYSTEM AND SIGNAL ANALYSIS II

III – 5e 3 1½ – 8

Modelling of physical systems. State representation of dynamic systems as vector matrix differential and difference equations. Linearization. Controllability and observability. Steady-state performance and stability analysis for constant, linear systems employing Bode diagrams, root loci, Routh and Nyquist criteria. Synthesis of elementary feedback compensators. (Prerequisite ELE 355F)

ELE 357F ELECTROMAGNETIC FIELDS

III – 5e, 5p (elective) 3 1½ 1 9

Wave propagation in linear electromagnetic media. Maxwell's equations and constitutive relations. Plane waves in dielectric and conducting media. Wave polarization. Poynting vector. Transmission lines. Smith Chart. Dielectric and optical waveguides. Retarded potentials. Small loop and short dipole antenna. Wave propagation in anisotropic media.

ELE 358S CONTROL SYSTEMS

III – 5nt, 5p (elective); IV – 5a, 5nt (elective) 3 1½ 1 9

As prescribed for ELE 356S. The tutorial will be used to provide problem solving competence in a few of the topics missing in the background of registrants who have not taken ELE 355F. (Prerequisite ELE 250S or ELE 211S with good standing. Exclusion ELE 355F)

ELE 359F SWITCHING THEORY

III – 5cs, IV – 5e (elective) 2 – 1 7

Combinational switching circuits. Minimization techniques. Functional decomposition. Threshold networks. Iterative arrays. Finite state sequential machine model. Synchronous machines. Asynchronous machines. Sequential machine decomposition. Linear sequential machine applications. Text: Z. Kohavi "Switching and Finite Automata Theory."

ELE 360S ELECTRONICS II

III – 5cs 3 1½ – 8

As prescribed for ELE 354S with special laboratory exercises.

ELE 400F PARTIAL DIFFERENTIAL EQUATIONS AND VARIATIONAL CALCULUS

IV – 7 2 – 2 8

Elliptic, hyperbolic and parabolic differential equations. Calculus of variations. (Prerequisites MAT 291F, ELE 200F, ELE 320F) Text: None. (Not offered in 1972–73)

ELE 405F SWITCHING THEORY

IV – 7 2 – 2 8

Boolean algebra, boolean functions, combinational networks, minimization techniques. Sequential machines, finite state models, synthesis, state assignment, state reduction. Asynchronous sequential machines. Combinations of sequential machines. Text: Kohavi "Switching and Automata Theory". (Prerequisite ELE 314S)

ELE 410F CONTROL SYSTEMS I

IV – 7 2 1½ 1 8

Review of steady-state and dynamic performance analysis, stability analysis and Bode diagrams. Linear compensation design. Process control design. Nonlinear control. (Prerequisite ELE 311S) Text: None

ELE 411S CONTROL SYSTEMS II

IV – 7 2 1½ 1 8

State representation for physical systems. Solution of vector-matrix differential equations. Calculation of transition matrices. Controllability and observability. Introduction to optimization. (Prerequisite ELE 410F) Text: None

ELE 412F NETWORK THEORY

IV – 5e, 7 (elective) 3 – 2 8

Network analysis and network functions. Properties and synthesis of RC and RL 1-ports. Positive real functions, testing, realizations. Properties of 2-port networks. Realization of lossless-singly- and doubly-terminated 2-ports. Texts: Humphreys "The Analysis, Design and Synthesis of Electrical Filters"; Balbanian "Network Synthesis". (Prerequisites ELE 211S, ELE 311S)

ELE 413F POWER SYSTEM ANALYSIS

IV – 7 2 1½ 1 8

Transmission lines, parameters and representation. Power system components. Behaviour of elementary power systems under normal and fault conditions. Texts:

Stevenson "Elements of Power System Analysis"; Neuenswander "Modern Power Systems". (Prerequisite ELE 313F)

ELE 414S POWER SYSTEM CONTROL

IV – 7 2 1½ 1 8

Load flows. Optimization problems. Voltage control. Relay protection. Stability. Reliability and reserve requirements. Texts: Stevenson "Elements of Power Systems Analysis"; Neuenswander "Modern Power Systems". (Prerequisite ELE 413F)

ELE 416S COMMUNICATION SYSTEMS

IV – 7 2 3 – 8

Review of signal analysis, Fourier analysis, probability and random processes. Bandpass signals. Amplitude modulation. Frequency modulation. Digital communication. Text: Sakrison "Communication Theory, Transmission of Waveforms and Digital Information". (Prerequisite ELE 311S)

ELE 419S ELECTROMECHANICAL SYSTEMS III

IV – 7 2 1½ 1 8

The theory of linear passive power invariant transformations is developed. Electromagnetic devices will be presented by flux linkage models which are then modified by various generalized transformations in order to facilitate their representation in systems requiring transient and steady state stability studies. A generalized co-ordinate transformation system for an m-n phase system revolving with respect to any arbitrary reference frame is developed and this is then reduced to the more classical phase, dq, or symmetrical component models. Evaluation of system parameters required for the models will be discussed. Text: Jones "Unified Machine Theory". (Prerequisite ELE 313S)

ELE 420F ELECTROMAGNETIC THEORY

IV – 7 2 – 2 8

Wave polarization. Rectangular and circular waveguides. Uniqueness of solutions. Wave propagation in the ionosphere. Radiation from wire antennas, simple arrays and continuous current distributions. Fields and impedance of a current-carrying conductor. Concepts of impressed, induced and equivalent sources. Reciprocity. Calculation of self and mutual impedance. Text: Jordan and Balmain "Electromagnetic Waves and Radiating Systems" 2nd ed. (Prerequisite ELE 320F)

ELE 421S RADIATION AND PROPAGATION

IV – 7 2 1½ 1 8

Microwave amplifiers and oscillators. Microwave components. Antenna arrays. Microwave communication systems. Formal solution of boundary value problems; Green's functions. Scattering by conductors. Diffraction by apertures. Fourier optics and holography. Spherical-earth propagation. (Prerequisite ELE 320F)

ELE 430F ELECTRONICS III

IV – 7 2 3 – 8

A design course considering the following topics: Bias design. DC coupling techniques. Multistage amplifiers. Frequency effects. Narrow band amplifiers. Feedback. Oscillators. Active filters. Modulation/Demodulation. Power amplifiers. Low noise techniques. Texts: Ghausi "Electronic Circuits"; Millman and Halkis "Electronic Devices and Circuits". (Prerequisites ELE 331S, ELE 211S, ELE 311S)

ELE 431S INTEGRATED CIRCUITS

IV – 7, IV – 5e (elective) 2 3 – 8

Design of integrated circuits with particular emphasis on the interaction between device and circuit design. Thin film and semiconductor integrated circuits. Design of integrated circuit components: capacitors, resistors, inductors, diodes, transistors. Linear and digital integrated circuit design techniques and limitations. (Prerequisites for IV - 7: ELE 336S, ELE 331S; for IV - 5e: ELE 352S, ELE 452F)

ELE 432S SWITCHING CIRCUITS

IV – 7. 5cs, 5e (elective) 2 3 – 8

Static and dynamic characteristics of semiconductor devices as switching elements. Transistor multivibrators. Integrated circuit logic families. Linear and non-linear waveshaping techniques. Flip-flops, registers, counters, encoders, memories. Text: None. (Prerequisites ELE 314S, ELE 331S)

ELE 433S POWER SEMICONDUCTOR CIRCUITS

IV – 7, 5e (elective) 2 3 – 8

Power semiconductor switches. Circuit transients. Study of inverter, converter and rectifier circuits with particular applications to DC and AC motor speed control and frequency conversion. Text: None. (Prerequisites ELE 211S, ELE 331S, ELE 314S)

ELE 435F SEMICONDUCTOR PHYSICS

IV – 7, IV – 5e (elective) 2 1½ 1 8

Selected topics in important physical concepts, allied to a deeper understanding of the properties of semiconductors, comprising: Crystal structure and crystal binding. Elastic waves. Phonons and lattice vibrations. Thermal properties. Theory of metals.

Band theory applied to semiconductors. Semiconductor carrier concentrations and transport. Text: McKelvey "Solid State & Semiconductor Physics"; Wang "Solid State Electronics". (Prerequisite ELE 336S)

ELE 436F QUANTUM PHYSICS

IV – 7 3 – 1 8

Development of Schroedinger equation and its application to simple models of atomic systems. Zeeman effect, angular momentum and electronic spin. Pauli principle and electron theory of atomic structure. Text: Slater "Quantum Theory of Matter"; Heitler "Elementary Wave Mechanics". (Prerequisite: Completion of all technical courses in the Third Year program in Electrical Engineering)

ELE 437S QUANTUM ELECTRONICS

IV – 7, IV – 5e (elective) 2 1½ 1 8

Theory of radiation absorption and emission; susceptibility, population inversion and maser action. Maser and laser materials and device properties, limitations and use of the devices; nonlinear behaviour of materials at optical frequencies. Text: Slater "Quantum Theory of Matter"; Heitler "Elementary Wave Mechanics". (Prerequisite ELE 436F)

ELE 440F COMPUTER PROGRAMMING AND DATA STRUCTURES

IV – 7, 5e (elective) 2 – 2 8

Programming languages; machine language programming, basic and macro assemblers, compilers. Data structures, properties of data types, stacks, queues. Tables, searching and sorting. Structure of an assembler. High level programming language. Text: TBA. (Prerequisites ELE 314S, APS 100)

ELE 441S COMPUTER ORGANIZATION

IV – 7, 5e (elective) 2 3 – 8

Computer organization: register implementations, register transfers, memory, control unit logic, instruction processing logic, execution unit, simple implementations of arithmetic operations. Microprogrammed control. Parallelism, pipelining. Interrupts. I/O processors. Stack machine organization. Text: TBA. (Prerequisite ELE 440F; Exclusion ELE 353F)

ELE 445S BIOMEDICAL ENGINEERING

IV – 7, 5e (elective) 3 1½ – 8

An introduction to some aspects of the interaction between engineering and medicine, given by the staff of the Institute of Bio-Medical Electronics and Engineering: Basic Anatomy and Physiology, Biological communication processes, Biological feedback and control, Bio-medical instrumentation, Cardiovascular measurements, Radiation diagnosis. Text: Selkurt "Physiology". (Prerequisite ELE 331S)

ELE 447F ILLUMINATION

IV – 7 3 1½ – 8

The course deals in general with the engineering problems which relate to the effective use of light (physical, physiological and psychological) in the everyday life of man. The topics covered include: The nature and characteristics of light; The production of light: incandescence and luminescence; The human eye, visual processes, and visual phenomena; radiometric and photometric units and laws; photometric measurements; calculation of photometric quantities; design of the visual environment: principles which relate to visual comfort and efficiency; colour and colorimetry; light sources – circuits and controls; visual problems at low light levels e.g. street lighting. Text: Sternes "Building Physics – Lighting". (Prerequisite ELE 235S)

ELE 450F TECHNIQUES OF SYSTEM THEORY

IV – 5e (elective) 2 1½ – 8

An advanced undergraduate course in multivariable system theory. Linear differential equations. Properties of linear systems – controllability, observability, equivalence. Stability concepts, perturbation results. Least squares theory. Applications such as observer theory, pole assignment. (Prerequisite ELE 356S, ELE 360S or ELE 311S with good standing)

ELE 452F ELECTRONIC CIRCUITS II

IV – 5e (elective) 2 3 – 8

Design of electronic circuits. Multistage amplifiers. Feedback amplifiers. Oscillators. DC amplifiers. Wideband amplifiers. Tuned amplifiers. Mixers. Detectors. Active filters. Negative impedance converters. Gyrators. Introduction to computer design of electronic circuits.

ELE 453F COMMUNICATIONS PRINCIPLES I

IV – 5cs, 5e (elective) 2 – 1 8

Probability theory, probabilistic formulation of the communication problem, representation of physical communication channels, Gaussian noise process, power spectrum, correlation function, vector model of a communication channel, error rate estimates, channel capacity theorem, analogue-digital digital-analogue conversion techniques, coding for transmission in noise. Textbook: *Principles of Communication Engineering* – Wozencraft and Jacobs.

ELE 454S COMMUNICATIONS PRINCIPLES II

IV – 5e (elective) 2 3 – 8

A study of the transmission and processing of digital information: Information sources; exponential error bounds and capacity theorems for coding and waveform channels; block and convolutional coding. (Prerequisite ELE 453F)

ELE 455S TECHNIQUES OF OPTIMIZATION

IV – 5cs, 5e (elective) 3 – 1 8

Linear and non-linear mathematical programming; dynamic programming; queuing theory; some problems in control theory; Monte Carlo methods. Applications will be drawn from engineering practice.

ELE 457S MICROWAVE ELECTRONICS

IV – 7; IV – 5e (elective) 2 1½ 1 8

Stability criteria for active electromagnetic systems. Wave Interaction in active media: Gunn diodes, IMPATT diode, Solid state lasers, etc. Coupled systems: travelling wave tube, backward wave oscillator, acousto-electric amplifiers. Parametric interactions: Manley-Rowe relations, design of parametric amplifiers and harmonic generators. Microwave magnetics: isolator, circulator. Microwave Acoustics: acousto-optic modulator. Passive components: resonators, couplers, and hybrid circuits. Laboratory experiments are associated with each of the above topics.

ELE 470F ELECTRICAL SYSTEMS

IV – 8 3 3 – 9

Electrical circuits, components, machines, sensors, transducers, instrumentation and controls with emphasis on practical applications, including heating and melting. Text: Electric Circuits and Machines (4th ed.) Lister.

ELE 496F THESIS

IV – 7 – – – 16

Each student in Electrical Engineering is required to write a thesis on an approved topic of his choice under the supervision of an academic staff member of the department. The thesis may involve experimental or other project-related activities. The weight to be attached to the thesis depends on the size of the thesis topic and must be approved by the student's thesis supervisor.

Further details are available from the Electrical Engineering Enquiry Office, G.146. (Prerequisite: completion of all third year technical courses. Exclusions: ELE 497S, ELE 498F, ELE 499S)

ELE 497S THESIS

IV – 7 — — — 16

Same as ELE 496F, but in spring term. (Prerequisite: completion of all third year technical courses. Exclusions: ELE 496F, ELE 498F, ELE 499S)

ELE 498F THESIS

IV – 7 — — — 8

Same as ELE 496F, but of smaller weight. (Prerequisite: completion of all third year technical courses. Exclusions: ELE 496F, ELE 497S)

ELE 499S THESIS

IV – 7 — — — 8

Same as ELE 498F but in spring term. (Prerequisites: completion of all third year technical courses. Exclusions: ELE 496F, ELE 497S)

DEPARTMENT OF GEOLOGY

GLG 120F PRINCIPLES OF PHYSICAL GEOLOGY

II – 9, III – 5g 2 3 – 9

Principles of physical geology and the evolution of the earth as a planet. The origin of the earth and the physical processes that operate on and in it. Topics include the composition and form of minerals and rock bodies, the deposition of sediments by rivers and oceans, the origin of mountain systems and the development of global structures. Air photographs, geological maps and cross sections are used in studying the effects of geologic processes. A field trip is taken in October.

J. B. Currie

GLG 122S PRINCIPLES OF HISTORICAL GEOLOGY

II – 9, III – 5g 2 3 – 9

A lecture-laboratory course that traces the history of the earth and its changing environments from the sequence of physical and biological events revealed in the rock record. Paleontology and concepts of geologic environments and time are emphasized in the laboratory and in the field. (Prerequisite GLG 180S or 120F)

G. Norris

GLG 180S APPLIED PHYSICAL GEOLOGY

I – 1, 3, 4, 5, 6, 7, 8, 9 (elective) 3 1½ – 8

Fundamentals of physical geology as related to engineering problems and practice. Configuration of the planet and the effects of external and internal processes that act upon it; influence of earth processes as a factor in the design of engineering structures. Students will gain a knowledge of earth materials – their occurrence and uses.

S. D. Scott

GLG 220 MINERALOGY

II – 9 2 4 – 9, 2 4 – 9

A first course in mineralogy and crystallography; the study of minerals as inorganic chemicals in the earth's crust; the use of crystal chemistry to explain optical, morphological and other physical properties of minerals; the formation, occurrence and classification of minerals and their identification both micro- and macroscopically. (Prerequisites CHE 100F, GLG 120F/180S, GLG 122S. Corequisites GLG 120F, GLG 122S)

D. H. Gorman, J. C. Rucklidge

GLG 221S GEOLOGICAL DATA PROCESSING BY COMPUTER

II – 9 (elective) 1 3 – 8

Applied mathematics, probability and statistics for processing geological data using computer methods. (Prerequisites APS 100F, GLG 120F/180S, GLG 122S. Corequisites GLG 120F, GLG 122S)

F. G. Smith

GLG 280S APPLIED PHYSICAL GEOLOGY

II – 1 2 1½ 1 8

A course similar to GLG 180S, but with alternate laboratory assignments.

GLG 320 PETROLOGY

III – 9 2 3 – 8, 2 3 – 8

The principles of petrology; the classification, description and interpretation of the sedimentary, igneous and metamorphic rocks. Microscopic petrography. Field work in first week of a 14-day field camp in the Tweed area immediately following the annual Third Year examinations. (Prerequisite GLG 220)

J. J. Fawcett

GLG 321F STRATIGRAPHY AND SEDIMENTATION

III – 9 2 1 – 6

The properties and classification of sediments and strata. Sedimentary environments and tectono-environmental concepts in stratigraphy; the influence of global tectonics on local stratigraphy. An 8-day field camp immediately following the annual Second Year examinations. (Prerequisite GLG 220. Corequisite GLG 320)

F. W. Beales

GLG 322 TECTONICS

III – 9 1 3 – 8, 1 3 – 8

Geometry of existing deformational structures in the earth's crust and reconstruction of their mechanical development. Field work in second week of a 14-day Field camp in the Tweed area immediately following the annual Third Year examinations. (Prerequisite GLG 220. Corequisite GLG 321F)

W. M. Schwerdtner

GLG 324 PHYSICAL GEOCHEMISTRY

III – 9 3 – – 8, 3 – – 8

Chemical thermodynamics, phase diagrams, electrochemistry, solution chemistry and ionic equilibria, kinetics with examples from natural and experimental mineral systems at a wide range of temperatures and pressures. (Prerequisite GLG 220)

S. D. Scott, G. M. Anderson

GLG 327S GEOLOGY OF THE CANADIAN SHIELD

III – 9 2 2 – 8

The stratigraphy, tectonic divisions and economic aspects of the Precambrian. Laboratory study of geological maps and reports; examination of typical rock suites in hand specimens and thin sections. (Prerequisite GLG 321F. Corequisite GLG 322)

A. M. Goodwin

GLG 421 MINERAL DEPOSITS

IV – 9 2 3 – 8, 2 3 – 8

Systematic mineralogy and phase equilibria of ore minerals. Identification of ore minerals in polished section. Geochemistry of ore-forming processes. Description of important ore deposits and discussion of their genesis. (Prerequisites GLG 320, 324)

GLG 422 EXPLORATION GEOCHEMISTRY

IV – 9 2 3 – 8, 2 3 – 8

Geochemical and geological aspects of mineral exploration, including characterization of target, nature of detectable halos surrounding target, typical survey methods and chemical analysis of materials obtained, statistical evaluation of data and elementary decision-making techniques. (Prerequisites GLG 220, 324)

S. E. Kesler, J. C. Van Loon

GLG 428F PETROLEUM GEOLOGY

IV – 9 2 3 – 8

Geological conditions of oil and gas entrapment within sedimentary basins. The occurrence of petroleum and natural gas pools. Exploration for energy resources. (Prerequisites GLG 321F, 322)

J. B. Currie

GLG 429S GEOHYDROLOGY

IV – 9 (elective) 2 3 – 8

Groundwater as an element of the hydrologic cycle; its relation to the geology of a basin and to water resources management. Groundwater distribution in Canada. Mechanics of groundwater flow; methods of investigation and exploitation. (Prerequisite GLG 428F)

J. B. Currie, V. Klemes

GLG 499S THESIS

IV – 9 – 6 – 8

Each student is required to prepare a thesis on an approved subject. Instructions will be issued by the Chairman of the Geological Engineering Course Committee.

DEPARTMENT OF INDUSTRIAL ENGINEERING

IND 200F ELEMENTS OF INDUSTRIAL ENGINEERING I

II – 4 2 – 2 8

History of Industrial Engineering, nature of modern Industrial Engineering, mathematical models of systems as a central concept of the discipline, consequences for curriculum design. Examples of case histories to illustrate idea of mathematical models of systems. Some models of wide applicability – linear programming and stochastic models with illustrations of their use in production and inventory models and in resource allocation.

B. Bernholtz

IND 201S ELEMENTS OF INDUSTRIAL ENGINEERING II

II – 4 2 – 2 8

A broad survey of the principles of productivity management including methods study and work simplification, plant location and facilities planning, value analysis, work measurement, production and inventory control, quality control, resources management and organization theories.

J. Vanderheyden

IND 202F COMPUTERS AND PROGRAMMING I

II – 4 2 – 2 8

Coding and programming for the digital computer; machine organization, machine language and symbolic compiler language (PL/1); number representation and conversion. Laboratory exercises are drawn from the fields of engineering and applied science, as well as from those of data processing and elementary compilation.

G. R. Comrie

IND 301F OPERATIONAL RESEARCH I

III – 4 2 – 2 8

An introduction, using simplified case studies, to the methodology, techniques and applications of operational research. (Prerequisites MAT 294S, STA 292S. Exclusions IND 331S, 431F, 432S)

A. A. Cunningham

IND 302S OPERATIONAL RESEARCH II

III – 4 2 – 2 8

Continuation of IND 301F, with greater emphasis on mathematical techniques. (Prerequisite IND 301F. Exclusions IND 331S, 431F, 432S)

A. A. Cunningham

IND 303F COMPUTERS AND PROGRAMMING II

III – 4 2 – 2 8

An extension of the Second Year subject Computers and Programming I. More advanced discussion of general and specialized compiler languages and their application in business, engineering and other fields; simulation, data processing, and list processor languages; Monte Carlo methods, GPSS, SIMSCRIPT, COBOL, etc. Laboratory problems are selected to complement the lecture material. (Prerequisite IND 202F)

R. W. P. Anderson

IND 304F INDUSTRIAL RELATIONS

III – 4 2 – 1 8

A discussion of trade unions, labour legislation and the collective bargaining process. (Prerequisite ECO 281/ECO 100. Exclusion ECO 344)

A. Kruger

IND 331S OPERATIONAL RESEARCH

III – 5cs, IV 5e 2 – 2 7

Processes of model building and solution. Problems of reliability, allocation, queueing, competition, sequencing, and co-ordination. Mathematical techniques of linear and dynamic programming, branch and bound methods, simulation, activity networks, and Markov processes. (Prerequisites APM 281F/386S/481F; MAT 295F/290F/294S/MEC 261F; STA 287S/282S/292S/CHE 305F. Exclusions IND 301F, 302S, 431F, 432S)

J. G. C. Templeton

IND 407F STATE SPACE METHODS IN PROCESS CONTROL

IV – 4 2 – 1½ 8

Short survey of systems engineering. State space representation of continuous and discrete-time systems. Solution of state space equations. Controllability and observability. Stability. Measures of system performance. Time-dependent parameters. Nonlinear processes. Stochastic processes. Business, engineering and socioeconomic applications. (Prerequisites APM 391F, MEC 357S)

J. G. Heller

IND 408S OPTIMAL CONTROL OF PROCESSES

IV – 4 2 – 1½ 8

Short survey of systems engineering. Goals and decisions; philosophical issues of value judgements. Computer process control. Steady-state process optimization. Well-defined process. Search techniques. Geometric programming. Adaptive control. Evolutionary optimization. Dynamic process optimization. Calculus of Variations. The maximum principle. Dynamic programming. Business, engineering and socioeconomic applications. (Prerequisite IND 407S)

J. G. Heller

IND 411F MAN AS AN INDIVIDUAL

IV – 4 2 – – 8

The study of individual differences in intelligence, achievement, aptitude and personality, as well as differences related to sex, age, racial and cultural factors. Problems and methods of measurement.

J. L. Vitalis

IND 412S ORGANIZATIONAL BEHAVIOUR

IV – 4 2 – – 8

Individual and group behaviour in work organizations. Relevance to human behaviour and management problems, supervision, communications, motivation and the implementation of change.

IND 413F FUNDAMENTALS OF MANAGEMENT SCIENCE

IV – 4 2 – 1½ 8

The course presents the basic principles of decision-making. It includes such concepts as the expression of individual choice by indifference curves, the analysis of data by Bayesian inference, the value of accurate information, and the use of cardinal utility to represent aversion to risk. The concepts are illustrated with industrial applications. (Prerequisite IND 302S)

T. A. Lambe

IND 414S APPLICATIONS OF MANAGEMENT SCIENCE

IV – 4 2 – 1½ 8

Algebraic procedures are presented for applying decision theory to processes where uncertainty is characterized by multinomial, normal and Poisson distributions. Examples include inspection sampling, equipment replacement and marketing. (Prerequisite IND 413F)

T. A. Lambe

IND 415S PRODUCTION SYSTEMS

IV – 4 2 – 1½ 8

Introduction to basic features of production systems and methods of modelling their operation. (Prerequisite IND 301F)

J. A. Buzacott

IND 416S ADVANCED INDUSTRIAL ENGINEERING

IV – 4 2 – 1½ 8

Methods of design, operation and control of systems of men and machines. (Prerequisite IND 303F)

I. B. Turksen

IND 417F STOCHASTIC MODELS

IV – 4 2 – 1½ 8

A course on the analysis of stochastic models in operational research. Review of relevant aspects of probability theory; Poisson processes and renewal processes; queueing models and Markov chains; applications to problems in electronic testing, traffic flows, reliability, inventory, etc. (Prerequisites IND 302S, APM 391F)

M. J. M. Posner

IND 418F SYSTEM SIMULATION

IV – 4 2 – 1½ 8

Computer simulation models. The theory will be developed and applied to problems in the design and analysis of queueing, inventory, maintenance, reliability, transportation, and resource allocation systems. (Prerequisites IND 302S, 303F)

I. B. Turksen

IND 419S INFORMATION AND OPTIMIZATION

IV – 4 2 – 1½ 8

Introduction to information theory; topics in optimization theory. (Prerequisite APM 381F)

J. G. C. Templeton

IND 420S MATHEMATICAL PROGRAMMING

IV – 4 2 – 1½ 8

Formulation of the linear programming problem, the simplex method (review), the revised simplex method, duality and the dual simplex method, postoptimality problems, parametric linear programming. Transportation problems, the fixed charge problem. Flows in networks. Integer linear programming, algorithms for the all-integer and the mixed integer-continuous problem. Fractional linear programming. Nonlinear programming. The Lagrangian function and its saddle points, Kuhn-Tucker theorem. Quadratic programming. (Prerequisite IND 302S)

J. Abrham

IND 421F MANAGEMENT INFORMATION SYSTEMS

IV – 4 2 – 1½ 8

Study of information systems in relation to both operational and decision-making activities in an organization; special attention to management planning and control activities. Models of information systems; manpower, logistics, and financial subsystems. Integrated systems. The roles of the information analyst and systems designer; the information processing organization; user implications. The development cycle of information processing systems; project control, implementation, and evaluation; equipment selection and configuration; file structures and software. Terminal-oriented systems. Case study projects. (Prerequisite IND 303F)

S. H. Cohn

IND 422F/S HUMAN FACTORS IN MAN-MACHINE SYSTEMS

IV – 4 2 3 – 8, 2 3 – 8

The course will be concerned with Human Factors from two points of view: (a) the anatomical, physiological and psycho-physical factors underlying the design of specific man-machine interfaces in specific environments; (b) the psychological factors involved in the determination of the allocation of function between men and machines in the overall system, specifically information processing capacity, acquisition and retention of skill, adaptability and stress.

The laboratory period will illustrate and emphasize experimental methods in these areas.

P. J. Foley

IND 431F OPERATIONAL RESEARCH I

IV – 8 (elective) 2 – 2 8

An introduction to operational research methodology, techniques and applications. Development of models and applications in the following areas are pursued: linear programming; graphs and networks; critical path analysis; dynamic programming. (Prerequisites MAT 294S, STA 282S. Exclusions IND 301F, 302S, 331S)

R. W. P. Anderson

IND 432S OPERATIONAL RESEARCH II

IV – 8 (elective) 2 – 2 8

A continuation of subject IND 431F in which queueing theory, inventory theory, stochastic processes and simulation are discussed. (Prerequisite IND 431F. Exclusions IND 301F, 302S, 331S)

R. W. P. Anderson

IND 497F TERM THESIS

IV – 4 – 6 – 8

Application of the methods and models studied in other Industrial Engineering subjects to an industrial engineering problem. The work will be carried out under the supervision of staff members. A written report is required.

Staff in Industrial Engineering

IND 498S TERM THESIS

IV – 4 – 6 – 8

As IND 497F.

IND 499 THESIS

IV – 4 – 6 – 8, – 6 – 8

Design and analysis of an engineering system to satisfy specified objectives and requirements. This project, extending over two terms, will provide the student with an opportunity to apply the knowledge and techniques of analysis acquired in his other Industrial Engineering subjects. The work will be carried out by students working in small groups, or individually, under the supervision of staff members. (May not be combined with IND 497F or IND 498S.)

Staff in Industrial Engineering

DEPARTMENT OF MATHEMATICS

MAT 180F MATHEMATICS I

I – 1, 3, 4, 6, 7, 8, 9 4 – 3 12

Calculus; limits, derivatives, integrals and their properties with applications, elementary functions. Basic concepts of linear algebra.

Staff in Mathematics and Staff in Engineering

MAT 181S MATHEMATICS II

I – 1, 3, 4, 6, 7, 8, 9 3 – 4 13

Vectors, matrices, linear systems, transformations, eigenvalues, linear programming, complex numbers. Applications of linear algebra and calculus.

Staff in Mathematics and Staff in Engineering

MAT 185S LINEAR ALGEBRA

I – 5 2 – 1 8

Vector spaces, matrices, linear transformations, eigenvalues, quadratic forms and quadratic surfaces.

P. Quinn, P. A. Sullivan

MAT 194F CALCULUS I

I – 5 3 – 2 10

Theory and applications of differential and integral calculus, continuous functions, mean value theorem, elementary functions.

D. K. Sen, L. T. Gardner

MAT 195S CALCULUS II

I – 5 2 – 1 7

Sequences, series, improper integrals, Taylor's theorem, differential equations, functions of several variables and partial derivatives.

D. K. Sen

MAT 280F CALCULUS AND DIFFERENTIAL EQUATIONS

II – 1, 6 3 – 2 9

Partial differentiation, maximum and minimum problems, multiple integration, ordinary differential equations and systems.

P. J. Rooney, R. Luus

MAT 289S COMPLEX VARIABLES

II – 5 3 – 1 8

Complex plane analytic functions, Cauchy's theorem, Taylor and Laurent series, singularities, analytic continuation, contour integration, conformal mapping, and applications.

C. Davis

MAT 290F DIFFERENTIAL EQUATIONS

II – 7 3 – 2 8

Linear ordinary differential equations and systems, series, transform and numerical solutions, nonlinear equations, introduction to partial differential equations.

MAT 293F CALCULUS

II – 3, 4, 8, 9 2 – 2 8

Functions of several variables, partial differentiation, maximum and minimum problems, Taylor series. (Prerequisite MAT 180F, MAT 181S)

D. Masson, J. Abrham, J. Corbett

MAT 294S CALCULUS AND DIFFERENTIAL EQUATIONS

II – 4, 8; II – 9A, 9C (elective) 2 – 2 8

Ordinary differential equations and systems, multiple integrals, curve integrals. (Prerequisite MAT 293F)

D. Masson, J. Abrham, J. Corbett

MAT 295F CALCULUS III

II – 5 3 – 1 8

Convergence and uniform convergence, linear differential equations, co-ordinate transformations, multiple integrals, line and surface integrals, orthogonal functions.

C. Davis

MAT 390S ALGEBRA

III – 5 3 – – 8

Vector spaces, dual spaces, linear operators and tensors, convexity and extremal problems, introduction to algebraic structures, Boolean algebras, elements of combinatorics.

MECHANICAL ENGINEERING

MEC 201S DYNAMICS I

II – 3 3 – 1½ 8

Calculus of vectors. Kinematics of bodies in rectilinear and curvilinear translation, rotation, and general motion. Spacecraft orbits. Impulse, momentum and moment of linear momentum. Conservative systems. Work-energy relations. Dynamics of motion. Euler's equations. Gyroscopic mechanics. Plane motion. D'Alembert's principle. Virtual work. Introduction to generalized co-ordinates, degrees of freedom, Lagrange equations. Introduction to mechanical vibrations and balancing.

F. P. J. Rimrott

MEC 205F DYNAMICS

II – 7 2 – 1 7

Dimensional units. Vectors. Kinematics, rectilinear and angular motion, place motion, projectiles, satellite orbits. Rigid body concept, relative motion with respect to translating and rotating co-ordinates, Euler's equations, gyroscopic effects. D'Alembert's principle. Vibration of mechanical and electrical systems, balancing. Work, energy, power, impulse, momentum. Rockets. Virtual work, Bernoulli's principle, introduction to Lagrange formulation. Reference Book: Vector Mechanics for Engineers – Dynamics – Beer & Johnston.

R. C. Flanagan

MEC 211F MECHANICS OF DEFORMABLE BODIES I

II – 3 3 ¾ 2¼ 10

Simple stress and strain. Concept of stress and strain at a point with treatment in 2-D cases (plane stress and strain). Principal stresses. Mohr's method. Yield criterion. Fatigue. Simple plasticity. Application to analysis of simple machine elements (beams, shafts, thin shells, joints, etc.). Properties of mechanical engineering materials (ferrous and non-ferrous metals, polymers).

D. McCammond

MEC 212S MECHANICS OF DEFORMABLE BODIES II

II – 3 3 ¼ 1¼ 8

Generalized equilibrium and compatibility relationships with application to axially symmetrical problems (thick cylinders, rotating discs). Theory of plates and shells. Thermal stress analysis. Energy methods. Experimental stress analysis methods.

D. McCammond

MEC 261F DIFFERENTIAL EQUATIONS

II – 3 3 – 3 10

First-order equations. Second-order equations. Operator techniques. Systems of equations. Power series for variable-coefficient equations. Numerical techniques.

A. W. Neumann

MEC 302S DYNAMICS II

III – 3, IV – 3 (elective) 3 – 1½ 10

Brief review of basic laws of classical Newtonian mechanics. Euler angles and gyrodynamics. Generalized co-ordinates and their transformation. Theorem of virtual work and d'Alembert's principle. Kinetic and potential energy. Dissipative power functions and Lagrange equations of motion. Determination of constraint forces. Variational dynamics. Hamilton's equations and principle. Astronautics. Orbital mechanics. Rocket mechanics.

R. C. Flanagan

MEC 303S VIBRATIONS

III – 3 3 ¾ 2¼ 10

Analysis of single degree of freedom systems. Various types of damping forces. Vibration isolation. Vibration measuring instruments. Steady state and transient vibrations. Vibration of multi-degree of freedom systems. Numerical methods of frequency analysis. Lagrange equations and Hamilton's principle. Energy methods. Vibration of strings, beams and plates. Torsion of shafts. Approximate methods. Introduction to non-linear vibrations. Introduction to wave propagation in solids.

D. L. Allen

MEC 313S ELASTICITY

III – 3 (elective) 3 – 1½ 10

Review of stress and strain tensors and generalization of Hooke's law. Equations of equilibrium and compatibility. Solution procedure using displacements and stress functions. Illustration of the theory by application to beams, rotating discs, thick composite cylinders, torsion of non-circular sections, stress concentration and thermal stresses. Introduction to finite difference and finite element methods of solution.

B. Tabarrok

MEC 315S EXPERIMENTAL STRESS ANALYSIS

III – 5nt, 5p (elective) 2 1 1 8

The elementary concepts of the theory of elasticity will be given. The experimental techniques of measuring stress or strain will be studied; these techniques include strain-gauge, photoelastic, brittle-coating and moire methods. Experimental work will be included.

G. E. Godfrey

MEC 321F THERMODYNAMICS

III – 3 3 3 – 10

Classical thermodynamic description of systems and processes; basic laws of thermodynamics; the Carnot argument, entropy, availability and criteria for equilibrium; nonreactive mixtures and ideal cycles.

C. A. Ward

MEC 322S THERMAL ENERGY CONVERSION

III – 3 3 3 – 10

The application of thermodynamics to heat engines, refrigerators and processes associated with useful energy transformations. Engine and turbine cycles for vapours and gases. Combustion processes. Psychrometry and air-conditioning. Direct energy conversion devices.

F. C. Hooper

MEC 323S COMBUSTION THEORY

III – 3 (elective) 3 1½ – 10

Fundamentals of combustion. Physical and thermo-chemical relationships of combustion. Mechanisms of burning. Ignition. Stabilization of flames. Limits of flammability. Laminar and turbulent flames. Diffusion flames. Practical combustion systems for gaseous, liquid and solid fuels.

A. B. Allan

MEC 326F STATISTICAL THERMODYNAMICS

III – 5nt 3 1½ 1½ 12

A development of thermodynamics in which the ensemble approach is used to treat isolated, closed and open systems. Such topics as the Liouville theorem, statistical equilibrium, partition functions, specific heats, and fluctuations in thermodynamic properties will be covered.

C. A. Ward

MEC 327F HEAT ENGINEERING

III – 5nt 2 3 – 8

This course consists of a study of the fundamental concepts of macroscopic thermodynamics, and their applications to closed and open dynamic systems. An examination of the principal power cycles is undertaken in relation to the properties of the working media involved. Emphasis is placed on a thorough understanding of the three basic laws of thermodynamics. Textbook: *Concepts of Thermodynamics* – Obert. Reference Books: *Engineering Thermodynamics* – Hall and Ibele. *Thermodynamics* – Van Wylen.

F. C. Hooper

MEC 341F FLUID MECHANICS I

III – 3 3 2 1 10

Introductory concepts. Fluid properties. Systems of stresses. Hydrostatics. Kinematics and dynamics of flow. Viscous laminar flow. Boundary layer theory. Turbulent flow. Internal and exterior flows.

J. F. Keffer

MEC 342S FLUID MECHANICS II

IV – 3 (elective) 3 1½ – 10

Kinematics of fluid motion: equation of continuity, stream functions, circulation and vorticity. Dynamics of ideal fluid flow: fundamental equations, fluids at rest, filament flow, potential flow. Dynamics of real fluid flow: fundamental equations, similitude, exact solutions, creeping flow, boundary layers. Turbulent flow: general features, wall turbulence, free turbulence. Diffusion processes: molecular diffusion, diffusion and convection in turbulent flow, dispersion in one-dimensional flow. Tutorials, films and selected experiments complementing lecture material.

H. J. Leutheusser

MEC 348S FLUID MECHANICS AND THERMODYNAMICS

III – 4 (elective) 2 3 – 8

Fluid properties and equation of state. Momentum and energy equations. Dynamics of flow, laminar and turbulent flow. Laws of thermodynamics. The Carnot cycle. Real and ideal fluids. Power cycles. Application of thermodynamics in various fields.

A. W. Neumann

MEC 349S TRANSPORT PHENOMENA

III – 8 3 1½ 1½ 8

A study of the forces and motion produced by various fluid properties. Gravitational, viscous and inertial forces are considered in detail. Momentum, energy and continuity relation, boundary-layer approximation, turbulence, flow in pipes and around submerged bodies. Steady-state conduction in one dimension; extended surfaces; heat conduction with two or more independent variables; forced convection and dimensional analysis; heat transfer by free convection; radiant heat transfer; heat transfer by combined conduction and convection; heat transfer in liquid metals.

A. H. Abdelmessih

MEC 351F FLUID MECHANICS

III – 1 3 3 – 10

Introduction: fluid and flow characteristics, dimensions and units. Fluid statistics: fundamental equation, gravity and inertia action, engineering applications. Fundamentals of one-dimensional flow: conservation principles of mass, energy and momentum, applications to ideal-fluid flow. Dimensional analysis and similitude. Fundamental concepts of real fluid flow: laminar and turbulent flow, boundary layer concept, flow about immersed objects. Flow in closed conduits: flow development, friction loss, minor loss, typical pipe-flow problems. Flow in open channels: uniform flow, varied flow. Special topics of interest to civil engineers. Tutorials, films and experiments complementing lecture material.

H. J. Leutheusser

MEC 354F FLUID MECHANICS

III – 5nt 3 3 – 12

A fundamental approach to the mechanics of fluid motion. Continuum concepts. Kinematics and dynamics of flow. Irrotational motion. Vorticity. Laminar flow solutions. Turbulent motions. Applications to conduit flow. Free surface waves. Fluid machinery.

J. F. Keffer

MEC 357S CONTROL ENGINEERING

III – 4 2 1 1 8

Introduction to the dynamic behaviour of linear systems. The feedback principle. Stability of linear control systems. The convolution theorem. Transfer functions of linear systems. Analysis of linear control systems. Introduction to servo-mechanism technology. Problems and laboratory experiments will accompany the lectures. (Prerequisite MAT 294S)

J. Vande Vegte

MEC 362F ENGINEERING ANALYSIS I

III – 3 3 – 3 10

Analytical techniques include Laplace transforms, series solutions of ordinary differential equations, special functions, vector calculus.

D. F. James

MEC 363S ENGINEERING ANALYSIS II

III – 3 3 – 3 10

Continuation of Engineering Analysis I. Topics include boundary value problems and eigenfunction expansions, higher-dimensional calculus, introduction to partial differential equations, functions of a complex variable.

D. F. James

MEC 371F ANALYSIS AND DESIGN OF MECHANISMS

III – 3 3 – 3 10

Analytical, graphical and computer techniques for kinematic analysis of mechanisms. Synthesis of linkages. Cams, gears and mechanism trains. Dynamic analysis including forces, balancing and control of speed fluctuation.

G. E. Godfrey

MEC 420F THERMAL ENVIRONMENTAL DESIGN

IV – 3 (elective) 3 1½ – 10

Psychrometrics, heating and cooling. Refrigeration including vapor compression, absorption and thermolectric. Solar radiation. Design and applications to the control of environmental systems in residential, public and industrial buildings and processes. Computer-aided design procedures.

A. H. Abdelmessih

MEC 424F THERMAL POWER GENERATION

IV – 3 (elective) 3 1½ – 10

Plants and processes in major power production. Overall design and heat balance in steam plants. Non-central power production. Characteristics of portable power units and auxiliaries.

A. B. Allan

MEC 425S MICROSCOPIC THERMODYNAMICS

IV – 3 (elective) 3 1½ – 10

The molecular approach to the description of thermodynamic systems. Ergodic hypothesis, ensemble averages, temperature and entropy. Fluctuations about the equilibrium states and rate processes.

D. S. Scott

MEC 428F THERMAL ENERGY CONVERSION I

IV – 5nt

3 3 – 11

The thermodynamics and gas dynamics of thermal energy conversion. Steam power cycles, fossil fuel energy sources, magneto-hydrodynamics, power generation, combustion, new trends and research developments.

A. B. Allan

MEC 429S THERMAL ENERGY CONVERSION II

IV – 5nt

3 3 – 11

Continuation of MEC 428F – including refrigeration and gas liquefaction, psychrometry and air conditioning.

P. S. Shen

MEC 431S HEAT AND MASS TRANSFER

IV – 3

3 1½ 1½ 9

Steady state and transient conduction, surface and gas radiation, convection, boiling, condensation and combined mechanisms of energy transport are considered, together with an introduction to mass transport. Application of these topics in the design of heat transfer equipment.

A. H. Abdelmessih

MEC 433S HEAT TRANSFER

IV – 5nt

2 – – 6

Steady state and transient conduction, surface and gas radiation, convection, boiling, condensation and combined mechanisms. Special attention is given to analogue and computational procedures and to consideration of the manner in which novel or complex problems may be approached.

F. C. Hooper

MEC 443S APPLIED FLUID MECHANICS

IV – 3

3 3 – 9

Pipe networks. One dimensional gas dynamics including simple area change, friction, heating, generalized flow and normal shock waves. Hydraulic transients including surges and water hammer. Flow machines. Other topics of engineering significance. Problems and experiments in applied fluid mechanics.

W. D. Baines

MEC 452S HYDRAULIC ENGINEERING

IV – 1 (elective)

3 2 – 8

Review of flow principles. Techniques of field measurement. Open channel and closed-circuit flow. Hydraulic structures and appurtenances, transitions, controls; dams; navigation works; methods of construction. Hydraulic machinery, pumps, turbines, power and control systems. Design and testing of hydraulic engineering systems; analytical procedures, numerical methods and computer simulation. Systems analysis.

G. D. Ransford

MEC 455F CONTROL SYSTEMS

IV – 3 3 1½ 1½ 10

Analysis and synthesis of linear feedback systems by frequency response methods and the rootlocus technique. Introductions to nonlinear control systems, the statespace technique, and digital computer control.

J. Vande Vegte

MEC 464F ENGINEERING ANALYSIS III

IV – 3 (elective) 3 – 1½ 10

This course covers the solutions of engineering problems which are described by partial differential equations. The physical problems treated involve heat conduction, fluid flow, vibrations, and stress analysis. The methods employed include separation of variables, integral transforms, eigenfunction expansions, Green's function methods, and some approximate techniques.

I. G. Currie

MEC 473S COMPUTER-AIDED DESIGN

IV – 3 (elective) 3 – 1½ 10

Value theory, decision theory. Modelling, numerical methods, problem oriented computer languages. Analytical optimization methods. Numerical optimization: linear, boundary and multi-dimensional search techniques; linear and dynamic programming. Reliability. Design simulation techniques. Computer graphics.

R. G. Fenton

MEC 475F MANUFACTURING ANALYSIS

IV – 3 (elective) 3 – 1½ 10

Introduction to plasticity. Mechanics of metal forming and machining processes. Tool wear. Machine tool vibration. Surface finish. Thermal effects in machining and forming. Economy of machining. Modern machining processes. Numerical and adaptive control of machines.

R. G. Fenton

MEC 495S ELASTICITY

IV – 3 3 – 1½ 10

Review of stress and strain tensors and generalization of Hooke's law. Equations of equilibrium and compatibility. Solution procedure using displacements and stress functions. Illustration of the theory by application to beams, rotating discs, thick composite cylinders, torsion of non-circular sections, stress concentration and thermal stresses. Introduction to finite difference and finite element methods of solution.

B. Tabarrok

MEC 499 THESIS

IV – 3 – – – 10, – – – 3

The student may choose a topic of his own preference from a list of topics prepared by the staff or he may use his own topic provided a staff member agrees to supervise the work. The thesis topic may be one of the following:

(i) an engineering design project
(ii) a research project
(iii) a state-of-the-art essay of an engineering problem

Full details of the thesis-project requirements are available on request from the Departmental Office.

DEPARTMENT OF METALLURGY AND MATERIALS SCIENCE

MMS 100S STRUCTURE AND PROPERTIES OF MATTER

I– 1, 3, 4, 5, 6, 7, 8, 9 (elective) 3 1½ – 8

An introduction to the structure and properties of the different states of matter in terms of the interatomic potential and thermal energy. A comparison of solids, liquids and gases, with special attention being directed towards crystalline solids. Specific topics considered include elasticity, viscosity, surface properties and capillarity, wave motion and the thermal and optical properties of matter. Textbook: *Gases, Liquids and Solids* – Tabor.

Staff in Metallurgy and Materials Science and Physics

MMS 201F STRUCTURE OF MATERIALS AND METALLOGRAPHY

II – 8 2 3 1 8

A course dealing with both the theoretical interpretation and the experimental determination of the structure of solids. Structure is discussed in terms of crystallography, defects in crystals, amorphous materials, polycrystalline grain structure and phase distribution in alloys. Metallographic techniques for the determination of microstructure by optical, x-ray, electron and field-ion microscopy are considered, as are quantitative metallography and the introductory principles of x-ray diffraction.

W. A. Miller

MMS 202F PHYSICAL CHEMISTRY I

II – 8 2 1 2 8

The physical-chemical properties of matter: ideal and real gases, liquids and solids, surface properties, viscous flow, and the concept of energy. Heat capacities and Debye's cubic law. Entropy and free energy for pure materials, order-disorder phenomena and configurational entropy. Introduction to solution properties and chemical equilibria. Ellingham diagrams and experimental methods. (Prerequisite MAT 180F)

S. N. Flengas

MMS 203S PHYSICAL CHEMISTRY II

II– 8, 9B 2 – 3 8

Phase diagram calculations – van't Hoff equations for the liquidus. Solid solubility under equilibrium conditions. Binary and ternary systems. Structure of liquids. Metallurgical systems such as the Fe-O, Fe-C and Fe-O-Si, are discussed in detail. Solubility of gases in liquid metals. (Prerequisites MMS 202F or MMS 225F)

J. M. Toguri

MMS 204S METALLURGICAL CHEMISTRY

I – 8 2 3 2 9

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber cycle and replacement reactions. Point defects, non-stoichiometry and conductivity. The Schroedinger equation and its solution in terms of orbitals. Bonding in condensed phases. The laboratory deals with the instrumental analysis of ores, concentrates, slags and alloys.

C. B. Alcock, H. U. Ross

MMS 205S MATERIALS SCIENCE

II – 8; III – 9B (elective) 4 – – 7

A course on the structure and properties of plastics, glass, ceramics, semi-conductors, and concrete. (*Staff in Chemical Engineering, Civil Engineering, Electrical Engineering and Metallurgy and Materials Science*)

MMS 221F MATERIALS SCIENCE

II – 7 3 1½ – 8

The physical and chemical properties of materials will be related to their microscopic structure. Atomic bonding, crystal structure (with special emphasis on Group IV and Group III-V semiconductors): Thermodynamics of ideal and real solids. Solid-state diffusion. Phase diagrams, phase transformations with examples. Single crystal growth. Mechanical properties: stress, strain and shear relations for isotropic and anisotropic materials; annealing, structural materials; fabrication processing. Corrosion.

J. W. Rutter

MMS 222F MATERIALS SCIENCE

II – 4, III – 9B (elective) 3 3 – 8

The effects of microscopic and atomic structures on the electrical, chemical and mechanical properties of engineering materials. The topics covered include atomic bonding, structures of ideal and real crystals, phase transformations and diffusion, chemical and mechanical properties, and oxidation and corrosion phenomena. The laboratory experiments will include x-ray studies of crystal structure; measurement of resistivity and magnetism of solids; studies of alloy phases and transformations; dislocation patterns, stress-strain relationships, stress-relaxation and fatigue phenomena; oxidation and corrosion reactions.

B. Ramaswami

MMS 223S MATERIALS SCIENCE

II – 3 3 1½ – 8

The effects of microscopic and atomic structures on the properties of engineering materials. The topics covered include atomic bonding and structures of materials, diffusion, crystal growth and solidification, plastic deformation and annealing, precipitation hardening, phase transformations especially in ferrous materials, relationships between structures and mechanical properties of metallic and non-metallic materials, and composite materials. The laboratory experiments are designed to illustrate the principles underlying the relationship between structures and properties of engineering materials.

K. T. Aust

MMS 224S INTRODUCTORY METALLURGY

II – 9B; III – 9A, 9C (elective) 2 – – 6

An introduction to the metallurgical processes used to extract metals from their ores and to refine and fabricate the final material into useful products. The course is designed around the flowsheets of processes for many of the most important metals.

H. U. Ross

MMS 225F PHYSICS AND CHEMISTRY OF MATERIALS

II – 9B 4 – 3 9

A course dealing with the structure of solids, liquids and gases. The physio-chemical properties of matter are considered from a thermodynamic viewpoint. (Prerequisite MAT 180F)

S. N. Flengas, W. A. Miller

MMS 226S INORGANIC CHEMISTRY

II – 9B 2 – 2 8

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber-cycle and replacement reactions. Point defects, non-stoichiometry and conductivity. The Schroedinger equation and its solution in terms of orbitals.

C. B. Alcock

MMS 227S MATERIALS SCIENCE II

II – 7 2 1½ – 7

The magnetic, dielectric and conductive properties of materials, as related to their structure. Magnetic properties: dia-, para-, ferro-, antiferro-, and ferri-magnetic phenomena; magnetic domains and domain wall motion; "hard" and "soft" magnetic materials, magneto-striction. Dielectric materials; insulating properties, conduction mechanism, dielectric loss. Ferro-electric materials. Electrical conduction; temperature, dependence, effect of composition and structure on conductivity. Thermoelectric phenomena. (Prerequisite MMS 221F)

U. M. Franklin

MMS 301F MINERAL PROCESSING I

III – 8, 9B; IV – 9A (elective) 2 3 – 8

The theory and practice of minerals beneficiation including particle size measurement, comminution, sizing, liquid-solid separation and ore concentration. The course also includes the relevant aspects of mineralogy, surface chemistry and the movement of solid particles in liquid media.

H. U. Ross

MMS 302F THERMODYNAMICS

III – 8, 9B 2 – 4 8

A study of chemical equilibria at high temperatures in extractive metallurgy – slag-metal reactions – classical theory of solutions – phase transformations – thermodynamic relationships in phase diagrams (Prerequisites MMS 203S, MAT 293F)

S. N. Flengas

MMS 303F PHYSICAL METALLURGY

III – 5m, 8 3 3 – 8

An introduction to the fundamental basis of microstructure control stressing the importance of alloying, plastic deformation and annealing. The principles of solidification, crystal growth, and phase transformations in solids, with particular reference to steels, are considered in detail.

U. M. Franklin, B. Ramaswami, J. W. Rutter

MMS 304S PHYSICS OF METALS

III – 5m, 8 3 3 – 8

Plastic deformation and mechanical properties are discussed in terms of dislocation theory. The annealing processes of recovery, recrystallization and grain growth and the structure and properties of interfaces in materials are also considered. (Prerequisite MMS 303F)

K. T. Aust, W. A. Miller, B. Ramaswami

MMS 305S EXTRACTIVE METALLURGY I

III – 8, 9B 4 3 – 9

A fundamental treatment of the pyrometallurgical processes involved in the production of the important metals, including oxidation of sulphides in the liquid and solid states, reduction of oxides and chlorides, matte-slag and metal-slag equilibria and kinetics and the distillation of metals. Experiments in materials processing, including roasting, smelting, leaching, refining, electrolysis. (Prerequisite MMS 302F)

C. B. Alcock, A. McLean, H. U. Ross, J. M. Toguri

MMS 306F METALLURGICAL THERMODYNAMICS

III – 5m 3 – 4 9

A study of chemical equilibria at high temperatures in metallurgy; slag-metal reactions; chemical theory of solutions; alloys; phase transformations; thermodynamic relationships in phase diagrams; statistical concept of entropy; simple partition functions; quasichemical approach to the theory of solutions; methods of investigating thermodynamic properties.

S. N. Flengas, A. McLean

MMS 307S MATERIALS SCIENCE

III – 5m

3 – – 8

A course dealing with the structure and properties of metals, alloys, glasses, and ceramics. (Prerequisite MMS 303F)

W. A. Miller, G. C. Weatherly

MMS 331F MATERIALS SCIENCE LABORATORY

III – 8 (elective)

– 3 1 8

Projects in materials science, chosen by the student, and carried out in close consultation with a staff supervisor. (Corequisite MMS 303F)

Staff in Metallurgy and Materials Science

MMS 332S EXTRACTIVE METALLURGY LABORATORY

III – 8 (elective)

– 3 1 8

A laboratory project in extractive metallurgy relating to course 305. (Corequisite MMS 305S)

Staff in Metallurgy and Materials Science

MMS 401F EXTRACTIVE METALLURGY II

IV – 8

2 3 1 8

Oxidation reactions, acid and basic steelmaking; transport considerations with reference to the open hearth, converter, B.O.F. and electric furnace steelmaking; continuous steelmaking processes, the influence of vacuum treatment and argon rinsing in steelmaking. The extraction and refining of metals by hydrometallurgical techniques in terms of thermodynamic and kinetic principles. (Prerequisite MMS 305S)

A. McLean, H. U. Ross, J. M. Toguri

MMS 402F SOLID STATE SCIENCE

IV – 5m, IV – 8

3 3 1 9

The course deals with relationships between crystal structure and the electronic and magnetic properties of solids, as well as the formation and stability of alloy phases and intermetallic compounds. The laboratory will be devoted mainly to x-ray and electron techniques applicable to both single crystals and polycrystalline materials. (Prerequisite MMS 304S)

U. M. Franklin, G. C. Weatherly

MMS 404S ELECTROCHEMICAL PROCESSES

IV – 8 (elective) 2 – 2 7

Electrochemistry of solids, liquids, and of high temperature systems. Fused salt electrochemical cells. Thermodynamics of imperfections and properties of ionic solids. (Prerequisite MMS 302F)

S. N. Flengas

MMS 406S ADVANCED CHEMICAL METALLURGY

IV – 8 (elective) 1 – 3 7

Selected topics related to the behaviour of metallic, ceramic and metal-slag systems at high temperatures. Thermodynamic and transport properties of alloys and metallic oxides, carbides, silicides, etc. High temperature corrosion reactions and vaporization processes. (Prerequisites MMS 302F, MMS 401F)

Staff in Metallurgy and Materials Science

MMS 407S METALLURGICAL SYSTEMS ANALYSIS

IV – 8 (elective) 2 – 1 7

The methods for evaluating metallurgical processes in terms of material resources and cost are considered together with the scientific factors which determine the choice of processes in order to obtain a synthesis of operational decision making. (Prerequisite MMS 401F)

Staff in Metallurgy and Materials Science

MMS 408S MATERIALS ENGINEERING

IV – 8 (elective) 3 – – 7

A course on the processing and selection of engineering materials. Processing techniques such as casting, metal working, welding, heat treatment, sintering and vapour deposition are considered. Factors governing materials selection are discussed in general and in relation to such specific applications as high and low temperature service, corrosion-resistant materials, nuclear materials, electronic materials, etc. (Prerequisite: any materials science course)

Staff in Metallurgy and Materials Science

MMS 409S HIGH TEMPERATURE PHYSICAL CHEMISTRY

IV – 5m 2 – 2 8

Properties of solids and liquids at high temperatures; thermodynamics of defects; solid oxide electrolytes; mechanism of electrical conductivity in ceramic phases; fused-salt electrolytes; reactions in fused-salt media; electrochemical cells at high temperatures; fuel cells; structural properties of simple and complex liquid phases; electrochemical corrosion and passivation; kinetics of heterogeneous reactions. (Prerequisite MMS 306F)

S. N. Flengas

MMS 410F THEORY OF METALLURGICAL REACTIONS

IV – 5m 2 – 2 8

Metal extraction and refining processes are examined in terms of chemical thermodynamics and kinetics. The principles and methods of extraction of ferrous and non-ferrous metals, roasting, leaching and electro-winning are typical of the subjects discussed. (Prerequisite MMS 306F)

J. M. Toguri

MMS 411S ADVANCED MATERIALS SCIENCE

IV – 5m; IV – 8 (elective) 3 3 – 8

This course is offered to those students whose primary interest lies in the research aspects of materials. Recent developments in materials science are discussed such as crystal growth, purification of materials, high-vacuum studies, preparation and characterization of clean surfaces, interfacial structures and properties, Auger emission and impurity segregation, environmental interactions. The laboratory work consists of research projects on contemporary problems in the field of materials science. (Prerequisite MMS 402F)

K. T. Aust, J. W. Rutter

MMS 412S MINERAL PROCESSING II

IV – 8, 9A (elective); III – 9B 2 1½ – 7

This is a continuation of course 301F. Topics considered include particle size analysis and characterization; the motion of solids in fluids under laminar, transitional and turbulent conditions and the application of surface chemistry to minerals and flotation. (Prerequisite MMS 301F)

H. U. Ross

MMS 431F POWDER METALLURGY

IV – 8 (elective) 2 – 2 8

Production and agglomeration of powders, the theory and practice of sintering, and the application of powder methods in the production of refractory metals, cemented carbides and other materials. (Prerequisite: any materials science course)

K. T. Aust, J. W. Rutter

MMS 499 THESIS

IV – 8 – 6 – 6, – 12 – 12

The student chooses an experimental problem involving original work, which normally is related closely to the current research of a staff member. The student is asked to prepare both a written report and an oral presentation describing the work. No laboratory time is specified for the engineering science (materials science option) thesis (APS 495) but the project is of essentially the same extent as that described above. (Prerequisites MMS 304S, MMS 305S)

Staff in Metallurgy and Materials Science

DEPARTMENT OF PHYSICS

PHY 180F ELEMENTS OF PHYSICS I (MECHANICS)

I – 5 2 1½ 1 9

Introduction to atomic and nuclear physics. Addition and multiplication of vectors with physical applications. Trajectories of particles. Rotational motion, conservation of angular momentum, moments of inertia, gyroscopes. Non-uniform accelerations, simple harmonic motion. Reaction kinematics. Philosophy of conservation laws and symmetries. Gravitational and other natural forces.

K. G. McNeill

PHY 181S ELEMENTS OF PHYSICS II (THERMODYNAMICS AND STATISTICAL PHYSICS)

I – 5 2 1½ 1 9

Heat and thermodynamics, the laws of thermodynamics with physical applications. Ideal gases, kinetic theory, Maxwell-Boltzmann distribution of molecular velocities, specific heats of monatomic and polyatomic gases. Basic probability notions, postulates of statistical physics, entropy, absolute temperature, the canonical distribution. Crystalline symmetry, elastic behaviour of solids. Dynamics of crystalline lattices, specific heats and solids, heat conductivity, thermal expansion.

D. G. Ivey

PHY 224S ELASTICITY AND FLUID MECHANICS

III – 5g, 5p 2 – – 8

A mathematical course in classical physics particularly for those interested in geophysics and meteorology. The elasticity part includes the definition and use of cartesian tensors to describe infinitesimal strains, stresses, and their relations. Fluid mechanics include fluid statistics, continuity, Bernoulli, Euler, and Navier-Stokes equations, potential flow, vortex flow. Textbook: R. R. Long – *Mechanics of Solids and Fluids*; D. R. F. Harleman – *Fluid Dynamics.*

J. V. Iribarne

PHY 225F GEOPHYSICS

III – 5p 2 – 1 8

A course in the physics of the earth, atmosphere and magnetosphere, offered to students in science. The principal conclusions reached by geophysicists about the planet, its evolution, and the processes taking place on it are introduced, as well as an outline of the methods utilized in attacking current research problems. Reference: Flohn – *Weather and Climate*; Gass, Smith and Wilson – *Understanding the Earth.*

R. List, G. Garland

PHY 280F ELEMENTS OF PHYSICS III (FIELDS AND WAVES)

II – 5 3 1½ 1 8

Principle of relativity, Lorentz transformation, Einstein's special relativity, relativistic dynamics, space-time geometry, the electromagnetic field, analysis of a vector field.

Matter in electrostatic and magnetostatic fields, electromagnetic field of uniformly moving charges, Maxwell's equations, radiation and its detection. Interference of electromagnetic waves, Huygen's principle and diffraction. Maxwell's equations in the presence of matter.

D. G. Ivey

PHY 281S ELEMENTS OF PHYSICS IV (QUANTUM PHYSICS)

II – 5 2 1½ 1 8

Classical systems and quantum systems. Wave-particle duality, Heisenberg uncertainty principle, electron and nuclear spin. Schroedinger equation. Eigenvalues and eigenfunctions. Transition probabilities. The harmonic oscillator. The hydrogen atom. Quantum aspect of electromagnetic radiation, quantum electrodynamics. Nuclear interactions, stable and unstable nuclei. Elementary particles – their production and interactions.

T. Drake

PHY 282F INTRODUCTION TO MODERN PHYSICS

II – 8, 9B 3 – 1 7

Quantum Mechanics. Statistical Mechanics. Atomic and Nuclear Structure. The Solid State. The Interaction of Electromagnetic Radiation and Matter.

T. Drake

PHY 283F BASIC CLASSICAL AND MODERN PHYSICS

II – 9 3 – – 8

A review of dynamics emphasizing the energy-momentum point of view and conservative systems; oscillatory and wave motion; an introduction to continuum mechanics and tensors; thermal physics including free energies and entropy; an introduction to quantum phenomena; basic explanations for the thermal, deformational and electrical properties of materials.

R. Desai

PHY 284S BASIC ELECTROMAGNETISM

II – 9 1 3 – 7

Alternating current circuits and fields, electromagnetic induction and wave propagation. This course normally follows PHY 283F and the laboratory includes experiments relevant to both.

G. J. Luste

PHY 303F THERMODYNAMICS

III – 5p 2 – – 8

The general principles of classical thermodynamics are discussed and related to statistical physics. Representative applications in fluids, solids, magnetic systems and phase transitions are considered. The kinetic theory of gases is treated.

G. M. Graham

PHY 304S SOLID STATE PHYSICS

III – 5g, 5m, 5p; IV – 8 (elective) 2 – – 8

Introduction to the basic features of solid state physics including: crystal lattices, propagation of waves in periodic structures, principal properties of metals, semiconductors, insulators, elements of magnetism. Description of crystal structures. Diffraction of x-rays by crystals. Classification and thermal properties of solids. Elastic constants of crystals. Lattice vibrations. Dielectric properties.

F. D. Manchester

PHY 305F NUCLEAR AND PARTICLE PHYSICS

III – 5p 2 – – 8

Important discoveries in nuclear and particle physics. Properties of the nucleus and of nuclei. The measurement of atomic masses; nuclear binding energies, binding energy and mass formulas, liquid drop model and fission. Introduction to nuclear shell and collective models. Interaction of charged particles and uncharged particles with matter; particle detection, energy and momentum measurements. Radioactive decay phenomena: theory and experiment. Nuclear reactions and cross sections. Particle accelerators. Reference Book: *Elements of Nuclear Physics* – Meyerhof.

D. A. L. Paul

PHY 307S APPLIED NUCLEAR PHYSICS

III – 5p 2 1 – 8

Fission and fusion. Tracer techniques. Biological effects of radiation. Applications of nuclear techniques in various fields. Neutron and scintillation radiography. Activation analysis. Textbook: *Nuclear Radiation Physics* – Lapp & Andrews.

B. M. Moores

PHY 308X EXPLORATION GEOPHYSICS

IV – 9 2 3 – 8, 2 3 – 8

An introduction to the physical principles underlying the important methods of geophysical prospecting. Particular attention is given to seismic, gravitational, magnetic and electromagnetic methods. Textbook: *Introduction to Geophysical Prospecting* – Dobrin.

G. F. West

PHY 309F MOLECULAR BIOPHYSICS

III – 5p 2 – – 8

The physical and chemical properties of some biologically important macromolecules in relation to their functions. Techniques such as sedimentation, chromatography, spectroscopy, scattering of photons and electrons. The course is designed to give students with a physics and chemistry background an insight into the application of the exact sciences to the solution of biological problems.

P. F. Ottensmeyer

PHY 310S CELLULAR BIOPHYSICS

III – 5p 2 – – 8

The emphasis will be on the application of principles from physics, chemistry and genetics to quantative studies in cell biology. Selected areas in biophysics such as cellular differentiation, the regulation of macromolecular biosynthesis, and the application of biophysical methods to problems in medicine, will be discussed in detail.

R. A. Phillips

PHY 327F MODERN PHYSICS LABORATORY

III – 5p – 6 – 10

Experiments of both a pure and applied nature are available in the areas of atomic, molecular, solid state, nuclear and particle physics. The experiments are open-ended; the student may spend more or less time on any particular experiment depending on his particular interest. The laboratory is open five days a week.

PHY 382S QUANTUM AND STATISTICAL MECHANICS

III – 5g, III – 5p 3 – – 8

Time independent and time dependent perturbation theory. Transition probabilities. Multielectron atoms. Classical Maxwell-Boltzmann statistics. Bose-Einstein and Fermi-Dirac Statistics. Statistical thermodynamics. This course builds on the material contained in PHY 181S and PHY 281S.

PHY 384F THERMODYNAMICS AND STATISTICAL MECHANICS

III – 7 3 – 1 7

The essential features of thermodynamics and statistical mechanics are obtained from an approach based on a quantum view of the statistical description of the microscopic behaviour of physical systems. Included are: the laws of thermodynamics, the concept of entropy, the concept of temperature, thermodynamic potentials and discussion of the distributions of Boltzmann, Fermi-Dirac and Bose-Einstein. Application of the general principles to electric, magnetic and radiation systems is stressed.

PHY 400C, PHY 400D QUANTUM THEORY I AND II

IV – 5p 2 – – 8, 2 – – 8

Waves and particles, wave packets, uncertainty principle. Schroedinger equation, expectation values, operators, eigenvalues, eigenfunctions. Matrix mechanics, angular momentum, central force problems. Pauli spin theory, identical particles, Pauli principle, applications to atoms and molecules. Zeeman effect. Perturbation theory, secular equations, time dependent perturbation theory, transition probabilities. Charged particles moving in electromagnetic fields, scattering theory.

D. Rowe, R. E. Pugh

PHY 401C STATISTICAL MECHANICS (Part 1)

IV – 5p 2 – – 8

Microcanonical, canonical, and grand canonical distributions, Bose-Einstein and Fermi-Dirac statistics. Applications to liquid helium, plasmas, phonons, photons and lattice-gas. Mean field approximation for phase transitions (magnetic systems and gas-liquid transition). Textbooks: Reif – *Fundamentals of Statistical and Thermal Physics*; Kittel – *Thermal Physics.*

P. A. Griffin

PHY 401D STATISTICAL MECHANICS (Part 2)

IV – 5p 2 – – 8

Theory of imperfect gases. Density fluctuations. Correlation functions. Kinetic theory of gases and application to irreversible phenomena. Derivation of Boltzmann transport equation for binary collisions and its solution. Textbooks: Reif – *Fundamentals of Statistical and Thermal Physics*; Kittel – *Thermal Physics.*

P. A. Griffin

PHY 403C NUCLEAR PHYSICS (Part 1)

IV – 5p 2 – – 8

General properties of nuclei and the nucleons. Nuclear masses, nuclear binding energy. Nuclear structure, meson theory and quark model. Nucleon-nucleon scattering phenomenology and the nucleon-nucleon force. The deuteron. Shell and collective models of nuclear structure. Textbooks: *Fundamentals of Modern Physics* – Eisberg; *Nuclear and Particle Physics* – Paul.

A. E. Litherland

PHY 403D NUCLEAR PHYSICS (Part 2)

IV – 5p 2 – – 8

Nuclear reactions. Alpha decay. Fission. Electromagnetic interactions: gamma decay, photonuclear reactions, electron scattering and electrodisintegration. Weak interactions: beta decay, inverse beta decay. Parity non-conservation and related phenomena. Textbooks: *Fundamentals of Modern Physics* – Eisberg; *Nuclear and Particle Physics* – Paul.

J. Goldemberg

PHY 404S HIGH ENERGY PHYSICS

IV – 5p 2 – – 8

Description of the elementary particles and their decay. Symmetries: charge independence (SU2), strangeness conservation, SU3 and quarks. Notions of scattering theory such as the S-Matrix, partial waves, unitarity, dispersion relations and Regge poles. Emphasis will be on the phenomenology. Textbook: *Elementary Particles* – Frazer.

R. K. Logan

PHY 405C SOLID STATE PHYSICS I

IV – 5p

2 – – 8

Crystal lattices, including lattice energies; wave propagation in periodic structures, including diffraction; phonons, thermal properties of solids, including specific heats, free electron theory, superconductivity. Textbook: Kittel – *Introduction to Solid State Physics* (4th ed.).

F. D. Manchester

PHY 405D SOLID STATE PHYSICS II

IV – 5p

2 – – 8

Energy bands, Fermi surfaces, electronic transport properties, homogeneous semiconductors, magnetism in solids. Textbook: Kittel – *Introduction to Solid State Physics* (4th ed.).

E. Fawcett

PHY 406F INTERACTION OF RADIATION WITH MATTER

IV – 5p

2 – – 8

A detailed survey with theoretical treatment and applications of: dispersion theory, shape and broadening of spectral lines, transition probabilities and intensities, scattering, diffraction and interference of electromagnetic waves, optical properties of metals and crystals, coherent radiation. Textbooks: *Principles of Optics* – Born and Wolf; *Optical Physics* – Garbuny; *Radiation and Optics* – Stone.

B. P. Stoicheff

PHY 407S MAGNETIC RESONANCE

IV – 5p

2 – – 8

Motion of free spins. Macroscopic aspects. Crystal fields and the effective spin Hamiltonian. Magnetic interactions in a rigid lattice. Thermal relaxation in liquids and gases. Thermal relaxation in solids. Electric quadrupole effects. Dynamic nuclear orientation. Textbooks: *Principles of Magnetic Resonance* – Slichter; *Paramagnetic Resonance* – Pake.

R. L. Armstrong

PHY 408F GROUP THEORY AND MOLECULAR PHYSICS

IV – 5p

2 – – 8

Abstract group theory. Theory of groups and group representations. Crystallographic point groups. Group theoretical matrix element theorems. Selection rules. Directed valence. Born-Oppenheimer approximation. Rotation and vibration of diatomic and polyatomic molecules. Textbook: *Group Theory and Quantum Mechanics* – Tinkham.

H. L. Welsh

PHY 409S QUANTUM OPTICS

IV – 5p 2 – – 8

Stimulated emission. Laser theory. Nonlinear optics including harmonic generation, parametric processes, stimulated scattering and self-focussing. Textbooks: *Nonlinear Optics* – Bloembergen; *Lasers* – Lengyel; *Quantum Optics* – Yariv.

A. D. May

PHY 410C, PHY 410D RELATIVITY THEORY I AND II

IV – 5p 2 – – 8, 2 – – 8

Special theory: principle of relativity, Lorentz transformations, Minkowski space, tensor algebra. Relativistic particle dynamics, collision theory. Relativistic field theory, hydrodynamics, Maxwell field, electrodynamics of material bodies, Klein-Gordon field. General theory: Principle of equivalence, general covariance, tensor analysis. Einstein equations, Schwarzschild solution, geodesics, gravitational collapse, black holes. Geometrodynamics, superspace, quantization of Einstein equations. Cosmology: cosmological models, Robertson-Walker metric, mix master universe.

J. Van Kranendonk

PHY 411 CLASSICAL PHYSICS OF CONTINUA

IV – 5g 2 – – 8, 2 – – 8

A course stressing the physical concepts underlying and the mathematical basis of continuum mechanics. Topics include deformation of continuous media, stress tensors, constitutive equations, viscosity, viscoelasticity, wave propagation, viscous hydrodynamics, stability theory, and possibly turbulence. The main emphasis is placed on problems relevant to the study of the earth. Textbook: Mase – *Continuum Mechanics* (Schaum's outline).

R. A. Wiggins

PHY 412 PHYSICS OF THE EARTH

III – 9, IV – 5g 2 – – 7, 2 – – 6

A course providing a physical background for the study of the interior of the earth and the development of its surface features. Topics include seismic waves and the earth's structure, the gravitational field and the earth's mass distribution, geomagnetism, geochronology, and the mechanical and thermal properties of the earth's interior. Textbook: Stacey – *Physics of the Earth*; Garland – *Physics of the Earth: Mantle, Core and Crust.*

G. D. Garland

PHY 413X THEORY AND APPLICATION OF GEOPHYSICAL METHODS

IV – 5g 2 6 – 12, 2 6 – 12

A course on the mathematical theory of seismic, magnetic electrical and gravitational methods in pure and applied geophysics. Considerable emphasis is placed on Fournier transform methods. Textbook: *Interpretation Theory in Applied Geophysics* – Grant & West; *Mining and Geophysics* – Parasnis.

PHY 414 ATMOSPHERIC PHYSICS

IV – 5g 2 – – 8, 2 – – 8

Meteorological measurements, radiation, atmospheric statics and conditions for equilibrium, atmospheric thermodynamics, equations of motion, synoptic charts, the general circulations, condensations, condensation physics, atmospheric electricity. Wind structure near the ground, evaporation, the stratosphere.

A. W. Brewer

PHY 427F QUANTUM PHYSICS LABORATORY I

IV – 5p – 6 – 8

This laboratory course is a continuation of PHY 327F. Students are expected to carry out the experimental work with more sophistication and finesse than in PHY 327F.

A. D. May, A. E. Litherland

PHY 428S QUANTUM PHYSICS LABORATORY II

IV – 5p – 6 – 8

This laboratory course is provided to allow the student to conduct experiments of a research nature under the direct supervision of a member of the Physics staff. In some cases, with the permission of the Chairman of Engineering Science, this project may be combined with the thesis APS 498S. A student wishing to enrol in this course is expected to seek out a supervisor of his choice and to choose a problem that is acceptable both to himself and to the staff member. A list of available staff and possible projects may be obtained from the Physics office.

A. D. May, A. E. Litherland

STATISTICS

(Department of Mathematics)

STA 282S PROBABILITY AND STATISTICS

II – 3, 8, 9 2 – 2 8

Elements of probability theory. Binomial, Poisson and normal distributions. Sampling theory. Significance tests. Control charts. Least squares.

A. Saleh

STA 287S PROBABILITY AND STATISTICS

II – 5 3 – 1 8

Definition of probability; binomial, Poisson, and normal distribution; frequency; sampling distributions. Examples of estimation, hypothesis testing, control charts, regression, and analysis of variance.

M. Srivastava

STA 291F PROBABILITY

II – 4 2 – 2 8

Elements of probability. Random variables. Discrete and continuous distributions. Moments. Independence. Conditional probabilities. Theory of sampling. (Prerequisite MAT 180F, MAT 181S)

J. C. Fu

STA 292S STATISTICS

II – 4 2 – 2 8

A continuation of STA 291F. Tests of significance and confidence limits. Control charts. Introduction to the analysis of variance, design of experiments and regression. (Prerequisite STA 291F)

J. C. Fu

STA 392S PROBABILITY AND STATISTICS

III – 4 2 – 2 8

A continuation of STA 292S. General regression theory. Elements of the theory of sample surveys. (Prerequisite STA 292S)

P. Andrews

ADDITIONAL COURSES

The courses listed below are not prescribed for any specific program, but are included in this section to bring them to the attention of interested students who may wish to choose one as an elective subject. The detailed course descriptions can be found in the appropriate calendar containing the listings of the departments offering the courses.

CHE 443	Organic Chemistry	2	–	–	6,	2	6	–	10
STA 347S	Probability and Applications					2	–	1	8

LIST OF IN-HOUSE NON-TECHNICAL ELECTIVES FOR 1972–73

The following in-house non-technical electives will be available to students in all four years in the session 1972–73. Two half courses or one full course may be taken as a non-technical elective by students in their first and second years, and as an open or free elective by students in their third and fourth years. All courses consist of two hours of lectures per week.

These courses will only be offered in a given term if there is sufficient enrolment, and the enrolment may have to be limited in some courses.

ECO 281 ECONOMICS

An introduction to the study of Economics with special reference to the problems of the Canadian economy. Those students who obtain a satisfactory term mark will not be required to write the final examination. This course has equivalent value to ECO

100 as a prerequisite for advanced courses in Economics. It may not be combined with ECO 100 or ECO 102 in any degree program.

ENG 281F/S EFFECTIVE WRITING

An "effective" writer knows how to express his ideas clearly and precisely, how to employ the laws of logic in ordering and supporting an argument, and how to use language persuasively. This course will involve discussion of the theory and method of various kinds of writing, supplemented by close consideration of examples of effective prose and by frequent and varied practical exercises designed to develop writing skills.

ENG 282F/S TWENTIETH-CENTURY LITERATURE

This course provides an introduction to twentieth-century literature through a study of representative works of important playwrights, poets, novelists and short-story writers.

ENG 283F/S CANADIAN LITERATURE

This course will deal with representative works of Canadian poets, novelists, short-story writers and essayists, and will consider some of the historical and cultural forces that helped to shape the Canadian imagination.

ENG 284F/S VARIETIES OF FICTION

This course is designed to increase enjoyment and understanding of the various forms of prose fiction (the novel, the novella, the short-story) through close consideration of representative works, including some recently written material.

ENG 285F/S DRAMA AND THE MODERN THEATRE

This course is designed to increase understanding and enjoyment of drama. It will deal with plays (of whatever period) which are still being performed in the contemporary theatre and will consider the reasons for their theatrical effectiveness for modern audiences. Where possible, attention will be given to filmed drama and to plays currently being performed in Toronto.

ENG 286F/S LITERATURE AND SCIENCE

This course will explore some of the ways in which the methods and discoveries of science have made and are making an impact upon literature and will deal with a selection of the wide variety of works (from metaphysical poetry to science fiction) which were written in response to the scientific and technological ideas of their time.

ENG 287S SPECIAL STUDIES IN ENGLISH

A course intended for students in ENG 281F, 282F, 283F, 284F, 285F, or 286F who may wish to continue studying the subject matter of their Fall-Term course rather than select a different option. Prerequisite: Consent of the instructor.

HPS 280F/S HISTORY OF SCIENCE AND TECHNOLOGY

An introduction and survey to the history of science and technology to show the growth and interaction of the two fields from the earliest times to the XXth century. Ideas originating within the two disciplines will be discussed along with their interactions and external influences.

HPS 281F HISTORY OF TECHNOLOGY AND ENGINEERING UP TO THE INDUSTRIAL REVOLUTION

A treatment of the origins of technology and engineering covering development in the civilizations of the Ancient World, that of Greece and Rome, the Medieval World and the period of the Renaissance. Emphasis will be placed on the developments of techniques and of machines with an indication of the context in which these occur.

HPS 282S HISTORY OF TECHNOLOGY AND ENGINEERING FROM THE INDUSTRIAL REVOLUTION TO THE PRESENT

A treatment of the development of machines and the utilization of new power sources during the period under discussion. The interrelation of new techniques and chemical processes with economic and other factors as well as the interaction between science and technology will be included. These courses may be offered in more than one section if demand calls for it.

HPS 283S TECHNOLOGY, ENGINEERING AND SOCIETY

An historical treatment of the interaction of technology, engineering and society. Material will be selected from throughout history, but concentration will be placed on the period since the Industrial Revolution where the nature of society is seen to be highly affected by technological developments and engineering accomplishments. The nature of the technical knowledge which permitted these changes will be discussed along with the adoption of the specific processes, machines and devices. Consideration will be given to the effects of man as a technological innovator on the environment and eco-system, including biological effects. (It is not considered at this time that attendance in this course should be limited, but if presumed attendance is too large for classroom discussion, it will be restructured to meet periodically in small groups.)

PHL 291F SCIENCE AND SOCIETY

A philosophical examination of the role of the scientist, technologist, and engineer in contemporary society, including some of the following problems: pollution, and its control, war research, the "think tank", technocracy, nationalism.

PHL 292S SCIENCE AND PHILOSOPHY

The advance of the physical, social, and life sciences has produced successive changes in concepts familiar to the ordinary man (space and time; cause and effect; man and animal; purpose, motive, freedom). The philosopher has attempted to work out the implications of these changes. This course will examine some of these attempts.

VII General Regulations; Examinations

The curriculum is based on a term system in which all courses of instruction (with the exception of certain courses taken in the Faculty of Arts and Science) will be one term in duration. There are two terms in the annual session, each concluding with final examinations in the courses offered. With the exception of the First Year, for which there are special provisions, students will be evaluated for promotion at the end of each term.

A regular program consists of a maximum of six courses per term with a total weight of 48 units; with the approval of the Chairman of his Department a student enrolled in the second or higher years may elect to reduce his load to a minimum of 40 units per term, or to increase it to a maximum of 60 units. First-year students may not take less than the normal load of 48 units.

I. DEFINITIONS

Fall Term Average – is calculated on the basis of all courses in which the student is enrolled at the start of the eighth week of the term, with the weighting factor for each course being the units assigned to it. The results of summer* or pre-session courses taken for credit will be included in the calculation of the Fall Term Average with their full unit value. The results of full-year courses taken in another Faculty will not be included in the calculation of the Fall Term Average, except in the case of certain courses for which arrangements have been made for the submission of marks on a term basis.

Spring Term Average – is calculated on the basis of all courses in which the student is enrolled at the start of the eighth week of the term with the weighting factor for each course being the units assigned to it. Full courses taken from other Faculties will be included in computing the average on the basis of their units for the spring term only. When the Fourth Year Thesis is spread over two terms and a department elects to report marks only at the end of the second term, the mark will have a weight equal to the sum of the Thesis weights for the two terms.

Year Average – is computed on the basis of the *final* marks and weights of all courses in which the student was enrolled in both terms, the weight of full-year courses being the sum of the term weights.

Core Course – any course in a program that is so designated by a Department.

*Approval to take a summer course for credit must be obtained in advance by writing to the Secretary, Faculty of Applied Science and Engineering.

Evaluation Period – the fall and spring terms taken together is the principal evaluation period for students who are taking First Year for the first time. For all other students, the evaluation period is a single term.

II. REGULATIONS

1. To qualify for a degree, a student must complete a full undergraduate program.

2. (*a*) The normal load is 48 units per term but a student may reduce his load to approximately 40 units or increase it to 60 units if his Department Chairman approves.

(*b*) Certain students are not permitted to reduce their academic loads, viz. students in First Year for the first time, or students who are required to repeat all of the courses in a term of one of the prescribed departmental programs.

(*c*) Students required to repeat courses and to whom regulation 2. (b) does not apply must carry a reduced load of approximately 40 units per term.

(*d*) In the final term a student may carry less than the normal minimum load of 40 units if the aggregate weight of the courses required for completion of his program is less than 40 units.

3. A student taking the First Year program in Division A who:

(*a*) Obtains a Fall Term average of 50% or greater proceeds to the next term.

(*b*) Obtains a Fall term average less than 50% will be required to withdraw until the next Fall Term, at which time he will be re-admitted without petition. Upon re-admission he must repeat* all courses for which his mark was less than 60, and is placed on probation.

(*c*) Obtains a Year Average of 60% or greater proceeds to the next term.

(*d*) Obtains a Year Average less than 60% but greater than or equal to 55% proceeds to the next term and is placed on probation.

(*e*) Obtains a Year Average less than 55% but greater than or equal to 50% must repeat* all courses from both terms for which his mark was less than 60% and is placed on probation.

(*f*) Obtains a Year Average less than 50% will be required to withdraw. (See regulations 7 and 8.)

4. A student taking the First Year program in Division B who:

(*a*) Obtains a Fall Term Average of 55% or greater proceeds to the next term in Division B.

(*b*) Obtains a Fall Term Average less than 55% but greater than or equal to 50% proceeds to the next term of a program in Division A.

(*c*) Obtains a Fall Term Average less than 50% will be required to withdraw until the next Fall Term at which time he will be re-admitted to Division A without petitioning. Upon re-admission, he must repeat* any course for which his mark was less than 60% and which has an equivalent in Division A and he is placed on probation.

(*d*) Obtains a Year Average of 66% or greater proceeds to the next term.

(*e*) Obtains a Year Average less than 66% but greater than or equal to 55% proceeds to the next term of a program in Division A.

(*f*) Obtains a Year Average less than 55% but greater than or equal to 50% proceeds to the next term of a program in Division A and is placed on probation.

(*g*) Obtains a Year Average less than 50% will be required to withdraw until the next Spring Term at which time he will be re-admitted to Division A without petitioning. Upon re-admission he must repeat* any spring-term course for which his mark was less than 60% and which has an equivalent in Division A and he is placed on probation.

5. Any student not covered under Section 3 or 4 who:

(*a*) Obtains a Term Average of 60% or greater proceeds to the next term and, if applicable, is removed from probation.

(*b*) Obtains a Term Average less than 60% but greater than or equal to 55% proceeds to the next term if not already on probation, and is placed on probation.

(*c*) Obtains a Term Average less than 55% but greater than or equal to 50% and is not already on probation is placed on probation and must repeat* all courses taken in that term for which his marks were less than 60. Normally any student in this category who must repeat more than two of his technical courses will be required to withdraw for one term.

(*d*) Obtains a Term Average less than 50% will be required to withdraw. (See regulations 7 and 8.)

(*e*) To be eligible for graduation a student must attain an average not lower than 60% in his final term; a student who fails to do so must repeat or replace courses to bring his average up to at least 60%. If a student's last term will involve less than the minimum academic load of 40 units he must repeat or replace courses to bring his average up to 60% in the penultimate term.

6. A student will also be required to withdraw from the Faculty if:

(*a*) He is on probation and fails to obtain at least a 60% average so as to remove himself from probation.

(*b*) He has been placed on probation twice before and obtains an average which would place him on probation again.

7. A student who is required to withdraw for the first time under regulations 3. (f), 5. (d) or 6:

(*a*) Must wait until one full term has elapsed before applying for re-admission.

(*b*) Will be considered for re-admission on his merits in competition with all other applicants.

(*c*) Must repeat,* if re-admitted, all courses taken in his last evaluation period for which his mark was less than 60% and is placed on probation.

8. A student who is required to withdraw for the second time under regulations 3. (f), 5. (d), or 6. (a) will not normally be re-admitted.

9. A student required to repeat courses can make up his academic load of approximately 40 units per term in the following ways, provided that his selections create no timetable conflicts:

(*a*) By taking courses from the next higher year of the program if he has obtained a mark of 50% or greater in the appropriate prerequisites taken in his previous evaluation period.

(*b*) By taking courses of comparable level to his failed courses. Normally these will not relieve the student of completing all the required courses in the program in which he is enrolled.

(*c*) By repeating courses which he has previously completed.

SUMMARY OF REGULATIONS FOR PROMOTION AND FAILURE

A_T = Term Average A_Y = Year Average

Evaluation Period	Average	Decision
Term 1 (First Year)	*Division A*	
	$A_T \geqslant 50\%$	Proceed to next term (Reg. 3a)
	$A_T < 50\%$	Required to withdraw for one term (Reg. 3b)
	Division B	
	$A_T \geqslant 55\%$	Proceed to next term (Reg. 4a)
	$50\% \leqslant A_T < 55\%$	Required to transfer to Division A (Reg. 4b)
	$A_T < 50\%$	Required to withdraw for one term (Reg. 4c)
Term 1 and 2 (First Year)	*Division A*	
	$A_Y \geqslant 60\%$	Proceed to next term (Reg. 3c)
	$55\% \leqslant A_Y < 60\%$	Proceed to next term on probation** (Reg. 3d)
	$50\% \leqslant A_Y < 55\%$	Repeat* all courses with mark less than 60% and go on probation** (Reg. 3e)
	$A_Y < 50\%$	Required to withdraw (Reg. 3f)
	Division B	
	$A_Y \geqslant 66\%$	Proceed to next term (Reg. 4d)
	$55\% \leqslant A_Y < 66\%$	Proceed to next term in Division A (Reg. 4e)
	$50\% \leqslant A_Y < 55\%$	Proceed to next term in Division A on probation** (Reg. 4f)
	$A_Y < 50\%$	Required to withdraw for one term (Reg. 4g)
All Other Terms	$A_T \geqslant 60\%$	Proceed to next term (Reg. 5a)
	$55\% \leqslant A_T < 60\%$	Proceed to next term on probation** (Reg. 5b)
	$50\% \leqslant A_T < 55\%$	Repeat* all courses with mark less than 60% and go on probation** (Reg. 5c)
	$A_T < 50\%$	Required to withdraw (Reg. 5d)

*Courses which are not designated as core courses need not be repeated but can be replaced by a course of comparable level.

**A student will be required to withdraw if:

(*A*) He is on probation and fails to obtain at least a 60% average so as to remove himself from probation. (Reg. 6a)

(*B*) He has been on probation twice before and obtains an average that would place him on probation again. (Reg. 6b)

GRADING SYSTEM

1. The student's work in individual courses is graded in the following manner:

Marks	*Grade*
80 – 100%	1
70 – 79%	2
60 – 69%	3
50 – 59%	4
Below 50%	5

2. Honour standing in the work of a term or a year is granted to students who achieve a weighted average of 75% or greater.

3. Honour graduate standing will be granted to students who obtain honours in the final year and in any one previous year.

ATTENDANCE

1. Students proceeding to the degree are required to attend the courses of instruction and the examinations in all subjects prescribed. A student whose attendance at lectures or laboratories, or whose work, is deemed by the Council of the Faculty to be unsatisfactory may have his registration cancelled at any time.

2. Students must conform to all lecture room and laboratory regulations. Reports, briefs, theses and drawings become the property of the Council to dispose of as it may see fit. Drawings, briefs and field notes will not be accepted unless they have been made at the time and place provided in the time table.

APPEALS

1. A student should submit to Council immediately after its occurrence, evidence of any illness or mishap which occurs during the term; any petition for leniency on account of such incidents may be refused consideration if received after the third day following the last day of examinations.

2. A student wishing to appeal to the Senate against a decision of the Council of the Faculty should consult the Secretary of the Faculty or the office of the University Registrar about the preparation and submission of his petition to the Secretary of the Senate.

VIII

Medals, Prizes, Scholarships and Bursaries

Through the generosity of friends of the University, governments and commercial organizations, encouragement has been given to undergraduate work in the various branches of engineering study by the establishment of the scholarships, prizes, bursaries and medals listed in the following pages.

ADMISSION SCHOLARSHIPS AND BURSARIES

Ontario Students:
Scholarships and bursaries available to students entering the First Year are listed on page 158. For full details concerning these awards, applicants should consult the Calendar of Admission Awards, which is available at Secondary Schools or from the Office of Student Awards, Simcoe Hall, University of Toronto. Applications, which must be made through the Principal of the Secondary School, close on May 1 annually.

Non-Ontario Students:
All non-Ontario students should apply to the Office of Student Awards, Simcoe Hall, University of Toronto. A limited number of scholarships is reserved for students living outside the Province of Ontario, but as competition is keen such students must not count on receiving assistance but are advised rather to ensure that they have sufficient funds from their own government or from private sources to cover all probable expenses.

IN-COURSE SCHOLARSHIPS AND BURSARIES

Scholarships, prizes, bursaries and loans available to students in attendance in the Faculty are listed on pages 165 to 168. Where it is necessary to make application for an award it is so stated in the description and particulars are given as to how the application should be made. In all other cases the award is made on the recommendation of the Faculty Council and no application is necessary.

GENERAL TERMS AND CONDITIONS

Scholarships, prizes and medals granted in recognition of academic proficiency are awarded at the end of the spring term, the candidates being ranked on the basis of their achievement in the spring term and the fall term previously completed.

To be eligible for any scholarship or award granted solely on academic standing a student must have completed not less than the normal full load within the two terms upon which the award is based. A student whose program in these two terms contains repeated courses will only be eligible if his aggregate of new courses is equal to or greater than 96 units.

Unless otherwise specified in the terms of award, scholarships, medals and prizes based solely upon academic standing will be awarded only to students who have achieved honours in the work upon which the award is granted. If the award is based on a single course or on a part of the work of the term, the candidate must obtain unconditioned pass standing in the work of the term, but need not obtain honours on the work of the term unless the terms of the award so specify.

A candidate will not be permitted to hold more than one award in a session unless the statute of each of the awards concerned or the calendar specifies otherwise. Only one of those awards marked with an asterisk may be held in any one year.

Medals, after they have been suitably engraved, will be given without delay to the winners or forwarded to them by registered mail.

Awards granted to members of graduating classes other than awards for graduate study and research, will be paid in one instalment as soon as possible after the granting of the awards.

All other awards will be paid (i) if of the value of $100 or less, in one instalment on November 20 and (ii) if of the value of more than $100 in two equal instalments, the first on November 20 and the second on January 20, in the session following the granting of the awards. Payment will be made only if the candidate is in regular attendance in the Faculty and, if the Calendar so specifies, in the course in which the award is established or granted.

The Senate may, on the recommendation of the Faculty, permit a candidate to whom an award has been granted to postpone attendance upon lectures and laboratory classes for one year. Further postponement may be permitted on application.

NOTE – As the value of an endowed scholarship or prize is dependent on the actual income of the fund, it is possible that the value of certain scholarships and prizes at the time of payment may be greater or less than the amount stated in the calendar.

In those cases where the amount of the award is not payable from income earned on an endowed fund, payment will be dependent on the receipt of the amount of the annual award from the donor.

AVAILABLE TO STUDENTS ENTERING THE FIRST YEAR
(† *indicates that application is required*)

Alumni Association War Memorial Scholarships	†	$ 500	page 193
J. P. Bickell Foundation Scholarships	†	$ 500	172
J. W. Billes Admission Scholarships	†		173
Children of War Dead Education Assistance	†		174
Engineering Alumni Admission Scholarships (7)	†	$1000	176
Grabill Admission Scholarship	†	$ 500	178
Hagarty Memorial Scholarship	†	$ 60	178
The Murray Calder Hendry Scholarship	†	$ 500	179
Roy Jarvis Henry Admission Scholarships (3)	†	$ 500	179
The Leonard Foundation Scholarships	†		181
J. Edgar McAllister Foundation Admission Awards	†	$1000	181
John Wolfe McColl Awards	†		181
Lachlan Dales McKellar Admission Scholarships (2)	†	$ 500	183
George R. Mickle Admission Bursaries	†	$1000	185
O.H.A. War Memorial Scholarship	†	$ 200	186
Ontario Chapter American Society for Metals Bursaries	†	$ 150	170
Ontario Student Awards Program	†		185
A.P.E.O. Admission Scholarship	†	$ 500	187
Regular Officer Training Plan	†		189
Helen E. Rogers Admission Scholarships	†		189
Simpsons-Sears Limited (Northern Ontario) Scholarship	†	$ 100	191
Walter Sterling Admission Scholarships	†		191
U.T.S. Engineering Scholarship	†	$ 250	193
Wallberg Admission Scholarships (6)	†	$1000	193

AVAILABLE TO STUDENTS COMPLETING THE FIRST YEAR
(† *indicates that application is required*)

Baptie Scholarship		$ 175	171
Canadian Bechtel Limited Bursaries	†		171
J. P. Bickell Foundation Scholarships			172
T. H. Bickle Prize		$ 30	172
Crocker Foundation Bursaries	†		175
John M. Empey Scholarship		$ 170	176
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		180
Johnson's Wax Scholarship		$ 800	180
John Wolfe McColl Awards	†		181
Garnet W. McKee-Lachlan Gilchrist Scholarship in Engineering Science		$ 110	182
MacLennan – MacLeod Memorial Prize		$ 25	183

*Marsland Engineering Ltd. Scholarship		$ 250	184
Ontario Chapter American Society for Metals Bursaries	†		170
Ontario Student Awards Program	†		185
Paulin Memorial Scholarship		$ 550	186
Procter and Gamble Bursary	†		186
*Professional Engineers Scholarship		$ 250	187
Ransom Scholarship in Chemical Engineering		$ 250	187
Frederick W. Schumacher Scholarship	†		190
S. Ubukata Fund	†		192
*Wallberg Undergraduate Scholarships (2)		$ 500	194

AVAILABLE TO STUDENTS COMPLETING THE SECOND YEAR
(*† indicates that application is required*)

Harvey Aggett Memorial Scholarship		$ 75	169
Ardagh Scholarship		$ 550	170
A.S.H.R.A.E. Bursaries	†		170
Automotive Transport Association Bursary	†		170
Babb Bursary Fund	†		171
Canada Student Loans	†		173
Canadian Bechtel Limited Bursaries	†		171
J. P. Bickell Foundation Bursaries	†		172
J. P. Bickell Foundation Scholarships			172
T. H. Bickle Prize		$ 30	172
Carveth Metallurgical Ltd. Bursary	†	$ 500	174
5T6 Civils Scholarship	†	$ 200	174
Crocker Foundation Bursaries	†		175
Cyanamid of Canada Scholarship		$ 900	175
John M. Empey Scholarship		$ 170	176
J. A. Findlay Scholarship		$ 100	177
Hugh Gall Award		$ 275	178
Hydro-Electric Power Commission of Ontario Bursary	†	$ 500	180
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		180
J. Edgar McAllister Foundation Bursaries	†		181
Charles Gordon Manning Prize			184
*Marsland Engineering Ltd. Scholarship		$ 250	184
James L. Morris Memorial Prize		$ 125	185
Ontario Chapter American Society for Metals Bursaries and Scholarship	†		170
Ontario Student Awards Program	†		185
*Professional Engineers Scholarship		$ 250	187
*Rhodes Scholarship	†	£1000	188
Frederick W. Schumacher Scholarship	†		190

Edith Tyrrell Memorial Bursary	†	$ 600	192
Wallberg Undergraduate Scholarship		$ 500	194
William R. Worthington Memorial Scholarship		$ 400	194

AVAILABLE TO STUDENTS COMPLETING THE THIRD YEAR

(† *indicates that application is required*)

American Institute of Industrial Engineers Scholarship		$ 150	169
A.S.H.R.A.E. Bursaries	†		170
Babb Bursary Fund	†		171
F. W. Baldwin Prize		$ 75	171
Canada Student Loans	†		173
Canadian Bechtel Limited Bursaries	†		171
J. P. Bickell Foundation Bursaries	†		172
T. H. Bickle Prize		$ 30	172
*Boiler Inspection and Insurance Company Scholarship		$ 300	173
*Chevron Standard Limited Scholarship		$ 500	174
Chemical Institute of Canada Prize		$ 25	174
Cominco Scholarships	†	$ 800	175
Sydney C. Cooper Bursaries	†		175
Crocker Foundation Bursaries	†		175
Dow Chemical of Canada Limited Award		$ 500	176
John M. Empey Scholarship		$ 170	176
E.I.C. Prize		$ 100	177
Engineering Society Semi-Centennial Award		$ 75	177
J. A. Findlay Scholarship		$ 100	177
James Franceschini Foundation Scholarship		$ 300	177
Chester B. Hamilton Scholarship		$ 500	179
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		180
*Jenkins Scholarship in Engineering		$ 200	180
Loan Funds	†		194
J. Edgar McAllister Foundation Bursaries	†		181
J. A. D. McCurdy Prize		$ 75	182
Alexander MacLean Scholarship		$ 250	183
*Marsland Engineering Ltd. Scholarship		$ 250	184
Ontario Chapter American Society for Metals Bursaries and Scholarship	†		170
Ontario Student Awards Program	†		185
*Professional Engineers Scholarship		$ 250	187
RCE Memorial Scholarship	†	$ 125	188
Rosedale Chapter, I.O.D.E. Award	†	$ 400	190
Don Salt Memorial Scholarships	†	$ 500	189

Murray F. Southcote Scholarship		$ 100	191
Frederick W. Schumacher Scholarship	†		190
Edith Tyrrell Memorial Bursary	†	$ 600	192
Wallberg Undergraduate Scholarship		$ 500	194
C. H. E. Stewart Bursaries	†		192

AVAILABLE TO STUDENTS COMPLETING THE FOURTH YEAR
(† *indicates that application is required*)

Henry G. Acres Medal			169
American Society of Lubrication Engineers Prize		$ 75	170
J. P. Bickell Foundation Bursaries	†		172
Babb Bursary Fund	†		171
Canada Student Loans	†		173
Sydney C. Cooper Bursaries	†		175
Crocker Foundation Bursaries	†		175
Electrical Manufacturing Co. Limited – Montel Inc. Prize		$ 50	176
Hamilton Watch Award			179
Loan Funds	†		194
J. Edgar McAllister Foundation Bursaries	†		181
Massey-Ferguson Ltd. Scholarships (2)	†	$ 500	184
Ontario Student Awards Program	†		185
Otto Holden Scholarship		$ 750	185
Professional Engineers Gold Medal			187
J. E. Reid Memorial Prize		$ 50	188
Wallace Award, Society of Automotive Engineers Prize		$ 100	191
Society of Chemical Industry Merit Award			191
"Second Mile Engineer" Award	†	$ 200	190
W. S. Wilson Medals			194

HENRY G. ACRES MEDAL

The Henry G. Acres Medal is the gift of Mrs. Henry G. Acres in memory of her late husband, Henry G. Acres, M.E., D.Sc., a graduate of the School of Practical Science in the class of 1903. Throughout his professional life Dr. Acres was associated with major power developments in Canada and abroad. As chief hydraulic engineer for the Hydro-Electric Power Commission of Ontario in the period 1911 to 1923, he was responsible for the design and construction of nearly twenty power plants, including the Queenston-Chippewa development. Entering private practice in 1924, and until his death in 1945, he continued to widen and extend his interests. He became chief engineer of the Grand River Conservation Commission and responsible for the design and construction of the Shand dam and related work. Later, he was consulting engineer for the extensive power developments at Shipshaw on the Saguenay River, which was vital to the production of aluminum for war purposes. Many of the provinces of Canada sought his services and he advised with respect to work in Newfoundland, South America and India.

This medal is awarded annually to the student in the Fourth Year who is registered in the course in Civil, Mechanical, or Electrical Engineering, and who obtains the highest aggregate percentage at the annual examinations of the Third and Fourth Years, provided always that the student obtains honour standing in the examinations of the Fourth Year. Receipt of the medal does not preclude a student from being granted such other award as may in the opinion of the Council be appropriate.

HARVEY AGGETT MEMORIAL SCHOLARSHIP

This scholarship was donated by the late Mr. J. T. Aggett, of Toronto, as a perpetual memorial to his son, the late Lieutenant Harvey Aggett, who enlisted in March, 1915, during his second year in this Faculty, and was killed in action at Passchendaele on November 6, 1917.

This annual scholarship of the value of the annual income from the fund is to be awarded to a student of the Second Year in this Faculty who, obtaining honours and being one of the first three in his year by his standing at the annual examnations, has been adjudged highest of the three in general student activities and service in the University during his period of attendance. When regulations do not permit the winner to hold this scholarship the students to be considered for the award shall be the first three in the year exclusive of any student who holds a scholarship of higher value.

AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS SCHOLARSHIP

The Toronto Chapter, American Institute of Industrial Engineers offers a scholarship of $150 to a student entering the Fourth Year of the Industrial Engineering course who has consistently maintained a high academic standing, but not necessarily honour standing, during the previous three years.

A.S.H.R.A.E. BURSARIES

The Ontario Chapter of the American Society of Heating, Refrigerating and Air-Conditioning Engineers provides a number of bursaries, to a total value of $1500 annually, for students in the Second and Third Years of Electrical Engineering and Mechanical Engineering. Candidates must reside in Metropolitan Toronto or in an adjacent municipality; the awards will vary in value, according to individual need and the fund available. Application should be made to the Secretary of the Faculty by October 15, on the regular in-course bursary application form.

AMERICAN SOCIETY OF LUBRICATION ENGINEERS PRIZE

The Toronto section of the American Society of Lubrication Engineers offers an annual prize of $75 to a student in the Fourth Year in Mechanical Engineering whose Thesis dealing with Lubrication is considered by the Head of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory. The Prize is accompanied by a donation of $25 to the Department to purchase books on Lubrication.

ONTARIO CHAPTER, AMERICAN SOCIETY FOR METALS BURSARIES AND SCHOLARSHIP

The Ontario Chapter, American Society for Metals, provides several bursaries of a value of $150 each for students in all years of Metallurgy and Materials Science and in the Third and Fourth Years of the Materials Science option of Engineering Science. Bursaries are awarded on the basis of academic ability and the need for financial assistance. Applications should be made to the Secretary not later than October 1st. The first award was made for the Session 1958–59.

The Ontario Chapter also provides one scholarship of a value of $250 for academic excellence to be awarded to a student in Metallurgy and Materials Science after completion of the Second or Third Year or the Materials Science option of Engineering Science (Third Year). The first award was based upon the results of examinations in the Session 1970–71.

ARDAGH SCHOLARSHIP

The Ardagh Scholarship, of the annual value of the income from $7,500, has been provided in memory of his parents by Professor E. G. R. Ardagh, B.A.Sc., F.R.S.C., formerly professor of Applied Chemistry in the Faculty. It is awarded to the student who attains the highest standing in all Honours at the annual examination of the Second Year in the Course in Chemical Engineering. The first award was made on the results of the annual examination of 1946.

ATA TRUCKING INDUSTRY EDUCATIONAL FOUNDATION BURSARIES

The Automotive Transport Association of Ontario has established a bursary fund for students in the second or higher years of any undergraduate degree course who find themselves in serious financial need due to sudden, unexpected personal or family difficulties. Applications may be submitted to the University Registrar at any time during the session and the number and value of the bursaries will vary at the discretion of the Committee of Award.

THE BABB BURSARY FUND

Bursaries from this fund are available to students in any year of the Aeronautics Option in Engineering Science. Application is made through the Secretary of the Faculty.

THE F. W. BALDWIN PRIZE

The F. W. Baldwin Prize of a value of $75 was established by the trustees of a fund created by the members of the Number 3 Squadron, University Air Training Corps (1941–44), in memory of Frederick Walker "Casey" Baldwin, a graduate of the School of Practical Science, who made a significant contribution in the field of Aeronautics in Canada; and who flew, on March 12, 1908, near Hammondsport, N.Y., the "Redwing," the first biplane built by the Aerial Experiment Association.

It is awarded annually to the student registered in Third Year, Aeronautics Option, in Engineering Science, who, taking honours, ranks highest in the annual examinations of Third Year in "structural subjects."

The first award was made on the results of the examinations of the Session 1953–54.

BAPTIE SCHOLARSHIP

The Baptie Scholarship is derived from a bequest under the will of the late Mrs. Margaret W. Baptie, of Ottawa, and the Board of Governors has directed that a scholarship of one half the annual income shall be awarded annually to an engineering student on the record of the first Year. The Board of Governors also authorizes a remission of fees in the case of the holder of the scholarship, up to $75.

The conditions of the award are as follows: That the scholarship be awarded to the student who, in the annual examinations of the First Year, enrolled in any one of the courses of Civil Engineering, Mechanical Engineering, Chemical Engineering, Electrical Engineering, or Metallurgy and Materials Science, obtains the highest aggregate percentage of marks in those subjects which are common to the First Year curricula of those courses. The first award was made on the results of the annual examinations of the Session 1925–26.

CANADIAN BECHTEL LIMITED BURSARIES

Canadian Bechtel Limited has established Bursaries in the Faculty of Applied Science and Engineering of an annual value of $1,200 to provide not more than four awards, each of a minimum value of $200 and a maximum value of $600. Two awards will be made to First Year students and one or two awards to students registered in any year of the Faculty. Applicants must demonstrate financial need and have academic standing satisfactory to the Faculty Council.

Application must be made to the Secretary of the Faculty on or before October 1.

J. P. BICKELL FOUNDATION SCHOLARSHIPS

The Trustees of the J. P. Bickell Foundation have established scholarships, the number to be determined annually, in the Faculty of Applied Science and Engineering of a possible value of $1,500 payable $500 in the First Year and provided honours are obtained at the Annual Examinations, $500 in the Second and Third Years.

An applicant must obtain an average of at least 75% at the Ontario Grade XIII examinations immediately preceding his admission to the university and must undertake to enrol in Chemical Engineering, Metallurgy and Materials Science or Geological Engineering. Failing suitable candidates in the courses mentioned students registered in the Second Year Honour course in Geological Sciences, or Physics and Geology in the Faculty of Arts and Science who are academically qualified are eligible. These awards are of the same value and are tenable in the Second, Third and Fourth Years of the course, subject to maintenance of the required academic standing. If any scholarships are not awarded to those mentioned above, students registered in the Third Year of the Engineering Science course in the Faculty of Applied Science and Engineering and taking the Physical Metallurgy or the Geophysics option who are academically qualified are eligible. In this case the scholarship will have a value of $1,000, payable $500 in each of the Third and Fourth years, provided the required academic standing is maintained.

Applications from those entering First Year must be submitted to the Office of Student Awards not later than May 1 on the regular admission scholarship application form. In other cases, applications are not required.

J. P. BICKELL FOUNDATION BURSARIES

The Trustees of the J. P. Bickell Foundation have established the J. P. Bickell Foundation Bursaries in the Faculty of Arts and the Faculty of Applied Science and Engineering. An applicant must be enrolled in Honour Science or in Mathematics, Physics and Chemistry in the Faculty of Arts, in which case he must undertake to study mining or geology in his higher years; or be enrolled in a higher year of an honour course in the geological or geophysical field in the Faculty of Arts; or be enrolled in Chemical Engineering, Mining Engineering, Metallurgy and Materials Science, or Geological Engineering in any year of the Faculty of Applied Science and Engineering. He must demonstrate financial need and have satisfactory academic standing.

Application must be made to the Office of Student Awards on or before October 15.

THE T. H. BICKLE PRIZE

The T. H. Bickle Prize is the gift of Mr. and Mrs. E. W. Bickle in memory of their son, T. H. Bickle, an undergraduate of Trinity College and a member of the Senior Intercollegiate Swimming Team at the time of his death in 1937. The income from the endowment fund will be used to purchase a suitable prize to be awarded annually to a member of the Senior Intercollegiate Swimming Team of this University in any year, faculty or school. The Committee of Award shall consist of the Dean of the Faculty of Arts, the University Registrar, the Director of Athletics, and the Honorary Coach of Swimming. In awarding the Prize the Committee shall consider the character, scholarship, and general interests of the members of the team.

J. W. BILLES ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of J. W. Billes, open to students entering any degree course in the University. The value in each year is a minimum of $250 and a maximum of $1,500 dependent upon the financial need of the recipient. Applicants must satisfy the normal admission scholarship standards in their Grade XIII examinations to be eligible for an award and maintain first class honour standing to enjoy the scholarship in higher years. The number of scholarships awarded in any one year may be varied dependent upon the available funds.

Application should be made to the Office of Student Awards by May 1 on the regular admission scholarship application form.

BOILER INSPECTION AND INSURANCE COMPANY SCHOLARSHIP

The Boiler Inspection and Insurance Company of Canada offers a scholarship in the Course in Mechanical Engineering of the value of $300 to the student who obtains highest honour standing in the regular examinations of the Third Year.

The successful candidate will be expected to proceed to his Fourth Year during the session next following the date of the award.

The amount of the award will be credited by the Chief Accountant to the fees of the Fourth Year of the successful candidate.

CANADA STUDENT LOANS PLAN

Full details of this Plan are available in a brochure issued each spring by the Government of Canada. Basically, the Plan is designed for those students who have resided in Canada for twelve months and demonstrate financial need, but who do not qualify for assistance under the Ontario Student Awards Program. Effective 1972, the maximum Canada Student Loan will be $1,400 per academic year. The application form for the Ontario Student Awards Program is also used for the Canada Student Loans Plan.

Application forms and brochures are available from the University of Toronto, Office of Student Awards, and all other post-secondary institutions, and should be submitted to the institution which the student plans to attend.

Students who intend to study outside Ontario or abroad should apply through the Department of Colleges and Universities, Mowat Block, Queen's Park, Toronto, Ontario.

CHEVRON STANDARD LIMITED SCHOLARSHIP

Chevron Standard Limited has presented a scholarship of $500 to a student who achieves outstanding results in the annual examinations of the Third Year in the Geophysics Option in Engineering Science or in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and Science.

The awards alternate annually between the Faculties of Applied Science and Engineering and Arts and Science and the First Award was made in the session 1960–61 in the Faculty of Applied Science and Engineering.

CARVETH METALLURGICAL LTD. BURSARY

Carveth Metallurgical Ltd. provides one or more bursaries to a total value of $500 for students entering the Third Year of Metallurgy and Materials Science. The award is made primarily on the basis of Second Year standing, but the need for financial assistance will also be taken into consideration.

The Bursary is available every third year, beginning in the Session 1961–62, and is to be awarded on the recommendation of the Department of Metallurgy and Materials Science. Application should be made by letter to the Secretary of the Faculty of Applied Science not later than September 1 of the year in which the award is tenable.

CHEMICAL INSTITUTE OF CANADA PRIZE

The Chemical Institute of Canada offers a prize of the annual value of $25 in books to the student registered in the course in Chemical Engineering who, having obtained honours, receives the highest standing in the written and laboratory work of the Third Year.

The first award was made on the results of the final examinations of 1947.

CHILDREN OF WAR DEAD (EDUCATION ASSISTANCE) ACT

Children of War Dead (Education Assistance) Act provides fees and monthly allowances for children of veterans whose death was attributable to military service. Enquiries should be directed to the nearest District Office of the Department of Veterans Affairs.

5T6 CIVILS SCHOLARSHIPS

The 5T6 Civils, consisting of the graduating members of the 1956 Civil Engineering Class of the University of Toronto, have established an annual scholarship of the value of $200 open to students who have completed the Second Year of the course in Civil Engineering and are registered in the Third Year of the course. The selection of the recipient is based on evidence of the qualities of scholarship, leadership and character. The award is not tenable with any other scholarship of greater value.

The award is presented at the annual reunion of the Class of 5T6 Civils. The first award was made in 1964.

Students who wish to be considered for this scholarship should write to the Class of 5T6 Civil Engineering, c/o Alumni House, University of Toronto, not later than December 31, giving full particulars of their academic record, and their extra-curricular activities both within and outside the University.

COMINCO SCHOLARSHIPS

Two scholarships, of an annual value of $800 each, are provided by Cominco Limited and are offered to students in the Third Year of the courses in Chemical Engineering, Geological Engineering, Mechanical Engineering and Metallurgy and Materials Science in the Faculty of Applied Science and Engineering and to students in the Third Year of the courses in Chemistry and Geology in the Faculty of Arts and Science, the awards being made on the basis of the examination results of the Second Year. The scholarships may be renewed in the Fourth Year if satisfactory standing is maintained.

Application must be made to the Secretary of the Faculty on the regular in-course awards form not later than October 15.

SYDNEY C. COOPER BURSARIES

An amount of $900 is provided annually for bursaries to be awarded to students in the Third and Fourth Years of the program in Civil Engineering who have achieved at least second-class standing in the previous year and who are in need of financial assistance.

Application must be made on the regular in-course bursary application form not later than October 15.

CROCKER FOUNDATION BURSARIES

The income from a capital fund established from the estate of the late Beatrice Crocker Glazier in memory of her brother, James William Crocker, provides bursaries for students in the Faculty of Medicine and the Faculty of Applied Science and Engineering who are in need and are worthy of financial assistance.

Application should be made to the Secretary of the Faculty not later than October 15.

CYANAMID OF CANADA SCHOLARSHIP

As a part of their program to encourage technical development in Canada, Cyanamid of Canada Limited offers a scholarship of the value of $900 to a student entering the Third Year in Chemical Engineering or Industrial Engineering. The award is made to a student who has demonstrated high academic ability and outstanding scholarship in the work of the Second Year.

The first award at the University of Toronto was made in 1964.

DOW CHEMICAL OF CANADA LIMITED AWARD

Dow Chemical of Canada Limited have provided funds for an annual award of $500 to a student in Chemical Engineering in the Faculty of Applied Science and Engineering, and grant-in-aid of $250 to be used in the winner's department to help defray the cost of equipment, supplies and administration.

The winner must:

(*a*) be registered in the Third Year in Chemical Engineering (the award will be made in the second terms of the Third Year and will be paid to the winner during his Fourth Year);

(*b*) be in the upper half of the class;

(*c*) have demonstrated leadership in extra-curricular activities.

The award is not tenable with other awards in the gift of the Senate. Application is not required.

THE ELECTRICAL MANUFACTURING COMPANY LTD. – MONTEL INC. PRIZE

The Electrical Manufacturing Company Limited has established an annual Prize of $50 in the Faculty of Applied Science and Engineering.

The winner must:

(*a*) be registered in the Fourth Year in Electrical Engineering;

(*b*) obtain the highest aggregate percentage of marks at the final examinations in the subjects of the Fourth Year related to electrical distribution equipment, the subject to be determined by the Head of the Department of Electrical Engineering.

This Prize is tenable with other awards in the gift of the Senate.

THE JOHN M. EMPEY SCHOLARSHIPS

The John M. Empey Scholarship Fund was established under a bequest of $10,000 in the Will of the late John Morgan Empey, B.A.SC., 1903. Three scholarships of equal value are provided from the income from the Fund. One of these scholarships is awarded in each of the First, Second, and Third Years on the results of the annual examinations, to a student who, taking honours, obtains the highest average percentage of marks in the written and laboratory subjects of his Year. The scholarships are open to any students registered in the Faculty. In case the winner of any one of these scholarships does not attend this Faculty during the session next following the award, the right to the scholarship shall be forfeited and the award shall be made to another eligible student. The scholarships were awarded for the first time in 1944.

ENGINEERING ALUMNI ADMISSION SCHOLARSHIP

Seven scholarships, each of the value of $1000, are provided annually by the University of Toronto Engineering Alumni Association for students entering the first year of any course in the Faculty of Applied Science and Engineering. The awards are made on the basis of standing in the Ontario Grade XIII examinations.

Application should be made to the Office of Student Awards by May 1 on the regular admission scholarship application form.

ENGINEERING INSTITUTE OF CANADA PRIZE

The Engineering Institute of Canada Prize, of the value of $100, is awarded annually to a Student Member of the Institute on the basis of the marks made at the completion of his penultimate year of undergraduate study, and on his activities in the Engineering Society or in the student branch of a recognized engineering Institute or similar organization.

ENGINEERING SOCIETY SEMI-CENTENNIAL AWARD

The Engineering Society Semi-Centennial Award, to the value of $75 was established in 1931 to commemorate the semi-centennial of the founding of the "School." The award is made to a student entering the final year.

The selection is based upon the following qualifications, which bear equal weight in the selection of the winner: (*a*) General "School" activities. (*b*) Contributions to the Engineering Society Executive Committee. (*c*) Personality, and social and athletic activities. (*d*) Academic standing.

J. A. FINDLAY SCHOLARSHIPS

These scholarships were established through a legacy bequeathed by the late Miss Janet Findlay to the Department of Mechanical Engineering. Two scholarships are available, each of a value of one half of the income of the fund, to students in this Course, one for a student in the Third Year, the other for a student in the Fourth Year, but only if the student continues his course in Mechanical Engineering. The selection will be made, on recommendation of the Head of the Department of Mechanical Engineering, from amongst the four students having the highest average percentage of marks at the annual examinations in the Second and Third Years respectively, but in making the award the student's general character, fitness for his profession, and financial circumstances will be given consideration. In case a student who has been awarded one of the scholarships changes his course or does not attend this University during the next following session, he shall forfeit his right to the scholarship and the award shall be made to another eligible student.

THE JAMES FRANCESCHINI FOUNDATION SCHOLARSHIP

This scholarship, of a value of $300, is awarded to the student in Civil Engineering who achieves the highest standing, with honours, at the annual examinations of the Third Year among those who do not hold an award of a value of $100 or more based on the results of these examinations.

HUGH GALL AWARD

The Hugh Gall Award was established in 1946 by the Graduate Class of 1910 "to commemorate a deceased classmate who was a splendid type of student, a loyal friend, and nationally outstanding in athletic achievement during his undergraduate career." Upon expiration of the original gift in 1951 the award was supported by Mrs. Hugh Gall until her death in 1970; under the terms of her will a sum of $5,000 was provided to support the award in perpetuity, the annual value of the award being the income from the bequest. The award is made to a student who, having completed his First Year with a general average of at least 66% without conditions, has entered the Second Year, and is in special need of financial assistance in order to enable him to continue his course. It is desirable, but not necessary, that the recipient shall not already have been given any other scholastic award or scholarship applicable to the second year and he shall have shown indications of his firm intention and ability to follow successfully the profession of engineering.

Any second year student in the Faculty of Applied Science and Engineering is eligible to apply for this Bursary. Applications should be made to the Secretary of the Faculty not later than October 15.

THE GRABILL ADMISSION SCHOLARSHIP

The Grabill Admission Scholarship is the gift of Mr. Dayton L. Grabill, a graduate of this Faculty in 1924. The Scholarship has a value of approximately $500. It is awarded to the candidate who has standing amongst those with the highest average percentages in the subjects of Ontario Grade XIII required for admission to the Faculty of Applied Science and Engineering. The candidate must write the Grade XIII examinations at one sitting in the June preceding entry to the University after not more than one year's instruction in Grade XIII and must register in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards on the regular Admission Scholarship form by May 1.

THE REGINALD AND GALER HAGARTY SCHOLARSHIP

The Reginald and Galer Hagarty Scholarship, in memory of the dearly beloved sons of Lieutenant-Colonel E. W. Hagarty, B.A. 1883, M.A. 1908, and Charlotte Ellen Hagarty, his wife. Reginald Edward Walter Hagerty, B.A.SC. (Honours) 1908, a graduate of the University in the Faculty of Applied Science and Engineering and at the time of his death on April 29, 1925, a Consulting Structural Engineer. Lieutenant Daniel Galer Hagarty, Princess Patricia's Canadian Light Infantry, a member of the class of 1916 in Applied Science, enlisted for the Great War at the end of his third year in June, 1915, killed in action in Sanctuary Wood, June 2, 1916. The scholarship is given in recognition of the fact that their father was an honour graduate in Classics of the University of Toronto. It is of the value of the annual interest on the capital sum of $2,000 and is to be awarded to a student who has been enrolled for his Grade XIII Year at Harbord Collegiate Institute and having obtained at least the required standing in each of the Grade XIII subjects necessary for admission to the Faculty, obtains the highest standing in English, a language other than English, and Mathematics, among the students who apply for the award from the Collegiate. He will be required to: (*a*) register in the Faculty of Applied Science and Engineering, (*b*) sign a declaration to the effect that he is willing to take up arms in the defence of Canada and the British Commonwealth should necessity arise as declared by the Parliament of Canada. The Scholarship was offered for award for the first time in 1945. Application should be made to the Office of Student Awards on the regular admission scholarship application form not later than May 1.

CHESTER B. HAMILTON SCHOLARSHIP

Members of the family of the late Chester B. Hamilton, a graduate of the Faculty in 1906, have presented a Scholarship in his memory of the annual value of $500. It is held by a Fourth Year student in Mechanical Engineering who has achieved outstanding academic standing at the Annual Examinations of the Third Year.

The first award was made on the results of the examinations for the Session 1958–59.

HAMILTON WATCH AWARD

Hamilton Watch Company, Lancaster, Pa., presents a wrist watch, suitably engraved, to the Fourth Year student in the Faculty of Applied Science and Engineering who at the annual examinations attains Honour standing and who has achieved high aggregate marks during his four years in the social-humanistic subjects common to all courses.

THE MURRAY CALDER HENDRY SCHOLARSHIP

This award was established by the estate of Mrs. Grace Appel Hendry as a memorial to her husband, a graduate of this Faculty in 1905. It has a value of the income from a capital sum of $10,000 and the recipient must:

(*a*) have attained an average of at least 75% on the grade XIII examination papers, written at one sitting, required for admission to the Faculty.

(*b*) be entering the First Year of any course in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards by May 1 on the regular University Admission Scholarship Application form.

The first award was made in the Session 1962–63.

ROY JARVIS HENRY ADMISSION SCHOLARSHIPS

The estate of the late Roy Jarvis Henry provides three scholarships of the value of $500 each, to be awarded to students who have achieved high standing on the

Ontario Secondary School qualifications required for admission, two of which are open to students entering any course in the Faculty and one open to students entering Geological Engineering. In the lack of a suitable candidate in Geological Engineering, all three awards are tenable in any course in the Faculty. Application must be made on the regular admission scholarship application form.

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO BURSARY

The Hydro-Electric Power Commission of Ontario has provided a bursary of the value of $500, which may be awarded to a student entering the second year of the courses in Mathematics and Physics or Commerce and Finance in the Faculty of Arts and Science, or any course in the Faculty of Applied Science and Engineering. Application should be made on the regular in-course bursary form not later than October 15.

IBM – THOMAS J. WATSON MEMORIAL BURSARY FUND

International Business Machines Company Limited has made available one or more bursaries of a total annual value of $1,000 to students registered in any year of a full time course in the university who have standing satisfactory to the committee of Award and demonstrate financial need.

Application should be made to the Office of Student Awards by October 15.

JENKINS SCHOLARSHIP

The Jenkins Scholarship, presented by Jenkins Bros., Limited, Montreal, first awarded in 1925, has been donated to continue indefinitely.

This Annual Scholarship, of the value of $200, is awarded to the student of the Third Year registered in any course of the Faculty who has the highest aggregate of percentages for the First, Second and Third Years.

JOHNSON'S WAX SCHOLARSHIP

S. C. Johnson and Son Limited, Brantford, Ontario, have established a Scholarship of an annual value of $800 in each of the Second, Third and Fourth Years or a total possible value of $2,400.

The recipient must:

(*a*) be registered in Chemical Engineering in the years in which the Scholarship is awarded and held;

(*b*) in the opinion of the Council be the most promising and deserving member of the class, obtaining Honours in the final examinations of the First Year;

(*c*) in his Second and Third Years, maintain academic standing satisfactory to the Council, not necessarily Honours, for the continued enjoyment of the Scholarship. In its discretion the Council may recommend the award of any portion of the Scholarship, lost by the original recipient by failure to maintain satisfactory academic standing, to another student of the year(s) in which the Scholarship would otherwise have been enjoyed.

The first award was made on the results of the annual examinations written in April 1954. It is not tenable with any other Scholarship.

THE LEONARD FOUNDATION SCHOLARSHIPS

Leonard Foundation Scholarships are awarded each year to selected students in Universities and Colleges across Canada, including the University of Toronto. The Trust Deed states: "Preference in the selection of students for scholarships shall be given to the sons and daughters respectively of the following: (*a*) clergymen, (*b*) school teachers, (*c*) officers, non-commissioned officers and men, whether active or retired, who have served in Her Majesty's military, naval or air forces, (*d*) graduates of the Royal Military College of Canada, (*e*) members of the Engineering Institute of Canada, (*f*) members of the Mining and Metallurgical Institute of Canada."

All applicants must be nominated by a member of the General Committee. The latest date for the receiving of applications is March 31, for the following academic year. Further information regarding the procedure to be followed in applying for these scholarships may be obtained by writing to the Leonard Foundation, c/o Canada Permanent Trust Co., 320 Bay Street, Toronto 1.

J. EDGAR MCALLISTER FOUNDATION BURSARIES

Through the generosity of the late J. Edgar McAllister, a graduate of the Faculty in 1895, a fund has been established in the University to be known as the J. Edgar McAllister Foundation, to provide financial aid for students who require it, in Mechanical, Chemical, Electrical and Geological Engineering and Metallurgy and Materials Science. Application should be made on the regular in-course bursary form not later than October 15.

J. EDGAR MCALLISTER FOUNDATION ADMISSION AWARDS

Provided for by the bequest of the late J. Edgar McAllister, B.A.Sc., twenty-five awards of the value of $1000 each are available to students entering the First Year of the programs in Mechanical, Chemical, Electrical and Geological Engineering and Metallurgy and Materials Science, who have achieved high standing in the secondary-school courses prescribed for admission and who are in need of financial assistance.

Applicants wishing to be considered for these awards should complete the financial need section on the regular University of Toronto Scholarship Application form, which is to be submitted not later than May 1.

THE JOHN WOLFE MC COLL MEMORIAL AWARDS

These six awards, two of which are open to students in the Faculty of Applied Science and Engineering, are the gift of the estate of the late John Wolfe McColl. The awards have a minimum value of $250 and a maximum of $750. Applicants must have obtained First Class Honours at the final examinations of the preceding year, whether Ontario Grade XIII or at the University of Toronto, demonstrate financial need and be enrolled or undertake to enrol in either Engineering Science or Chemical Engineering. Students seeking first admission to the University must submit applications for an award to the Office of Student Awards on or before May 1. Students in the University must submit applications for an award to the Registrar of the University on or before October 15.

THE J. A. D. MC CURDY PRIZE

The J. A. D. McCurdy Prize of a value of $75 was established by the trustees of a fund created by the members of the Number 3 Squadron, University Air Training Corps (1941–44) in honour of John Alexander Douglas McCurdy, a graduate of the School of Practical Science, who "made the first flight in Canada on February 23, 1909, with a heavier-than-air machine."

It is awarded annually to the student registered in Third Year, Aeronautics Option, in Engineering Science, who, taking honours, ranks highest in annual examinations of the Third Year in the subjects related to Aerodynamics.

The first award was made on the results of the examinations of the Session 1953–54.

THE GARNET W. MCKEE-LACHLAN GILCHRIST SCHOLARSHIP IN ENGINEERING SCIENCE

Mrs. Garnet W. McKee and Professor Lachlan Gilchrist each contributed $1,000 to provide for a Scholarship in the First Year of the Course in Engineering Science. The value of the Scholarship is the annual income from the capital fund and is awarded to the student who ranks first in honours at the annual examinations of the First Year in the Course in Engineering Science. If for any reason that student is ineligible to hold the Scholarship, it will be awarded by reversion to the student ranking second in honours in the Course. In order to receive payment the winner must register in the Second Year of the Course in Engineering Science. The Scholarship was awarded for the first time on the results of the annual examinations of 1947.

THE GARNET W. MC KEE-LACHLAN GILCHRIST GEOPHYSICS SCHOLARSHIPS

Financial assistance was received by Professor Lachlan Gilchrist of the Department of Physics, University of Toronto, from certain organizations and individuals to help him in the prosecution of his research work in Geophysics. With the consent of the contributors, the unexpended balance of these gifts was transferred by Professor Gilchrist to the Board of Governors of the University to be used as an endowment for scholarships, two of which were established in the Faculty of Applied Science and Engineering. To this fund have been added additional amounts received from the estate of the late Garnet W. McKee and from the Hollinger Consolidated Gold Mines Ltd. They are awarded by the Senate, on the recommendation of the Council of the Faculty of Applied Science and Engineering. The first awards were made on the results of the Annual Examinations of 1941.

The First Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $200 is awarded to the student in the Second Year in the Course of Engineering Science who obtains the highest aggregate standing at the examinations of the First and Second Years in the Course, provided always that the student obtains honour standing at the examinations of the Second Year.

The Second Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $165 is awarded to the student in the Second Year in the Course of Engineering Science who, of those students who elect to proceed in the Third Year in the Geophysics Option of the Course, obtains the highest aggregate standing at the examinations of the First and Second Years, provided always that the student obtains honour standing at the examinations of the Second Year, and excluding always the student to whom the First Lachlan Gilchrist Geophysics Scholarship has been awarded.

If in any year there is no student who has fulfilled the condition as laid down for the Second Lachlan Gilchrist Geophysics Scholarship, it shall be awarded to the student in the Second Year in the Course in Engineering Science who obtains the second highest aggregate standing at the examinations of the First and Second Years of that Course, provided always that such student obtains honour standing in the examinations of the Second Year.

LACHLAN DALES MC KELLAR ADMISSION SCHOLARSHIPS

Provided by a bequest of the late Leona D. McKellar, two scholarships of the value of $500 each, are offered to students who have achieved high standing on the Ontario Secondary School qualifications required for admission to the Faculty. Application must be made on the regular admission scholarship application form.

THE ALEXANDER MAC LEAN SCHOLARSHIP

This scholarship was established by graduates of the University of Toronto and other friends in honour of Professor Alexander MacLean, B.A. (1908) who retired in 1954. The scholarship, of the value of $250, is awarded to a student in the Third Year of Geological Sciences, Faculty of Arts, or in the Third Year of Geological Engineering, Faculty of Applied Science and Engineering, who, obtaining not less than 75% in the work of the year, obtains the highest standing in the geological subjects common to the two courses.

The first award was made in 1955.

MAC LENNAN-MAC LEOD MEMORIAL PRIZE

The Graduating Class of 1910 has donated an annual prize, known as "The MacLennan-MacLeod Memorial Prize," in memory of their first Class President, George MacLennan, who was killed in action in France in 1917, and of Doug. MacLeod, their first Secretary, who died in France in 1916 from wounds received in action.

The prize, of the value of $25, is awarded to the First Year student in the Faculty of Applied Science and Engineering who ranks highest in Calculus among those who obtain standing without condition at the annual written examinations; or, in the event of more than one student obtaining equally high rank in Calculus, the award is made to the one of these who also has the highest standing in some other subject common to the competitors, such as Analytical Geometry, such subject to be determined by the Council of the Faculty.

An award will not be made in any year in which, in the opinion of the Council, no student obtains a sufficiently high standing in Calculus to merit the award. If in any year no award is made, a second award will be available in the subsequent year.

CHARLES GORDON MANNING PRIZE

The Charles Gordon Manning Prize was established by a bequest under the Will of the late Jennie Manning in the amount of $500, the annual income from which is to be used to buy books for the winner of the Prize.

The recipient must be enrolled in the Second Year of a course offered by the Faculty of Applied Science and Engineering and, in the opinion of the Council, rank second to the student awarded the Harvey Aggett Memorial Scholarship in the considerations specified for the award of that Scholarship, namely, obtaining honours in his final examinations and being one of the first three in his year by his standing at those examinations relative to the pass requirements in his Department and being "adjudged highest of the three in general student activities and service in the University during his period of attendance."

The first award was made on the results of the annual examinations of 1954.

MARSLAND ENGINEERING LIMITED SCHOLARSHIP

The Marsland Engineering Limited Scholarship, the gift of Marsland Engineering Limited, has a value of $250. It is awarded to the student who, having been granted a Dominion-Provincial Student Aid Bursary in his First Year, is registered in Mechanical or Electrical Engineering and obtains the highest average percentage of marks, with honours, at the annual examination of the First, Second or Third Years in the session in which the award is made.

The first award was made at the annual examinations of 1954.

MASSEY-FERGUSON LIMITED SCHOLARSHIPS

Massey-Ferguson Limited has established two scholarships each of an annual value of $250, to be awarded on the recommendation of the Council of the Faculty of Applied Science and Engineering to students registered in the Fourth Year of the Courses in Mechanical Engineering or Industrial Engineering. In making the award academic achievement, financial need, extra-curricular activities and such other factors as may be deemed appropriate will be taken into consideration.

Application should be made to the Secretary of the Faculty not later than October 15.

GEORGE R. MICKLE ADMISSION BURSARIES

Provided for by a bequest of the late George R. Mickle, five bursaries of the value of $1000 each are available to students entering the First Year of courses in the Faculty of Applied Science and Engineering. The awards are made on the basis of the applicant's academic standing in Grade XIII, and his need for financial assistance. Applicants wishing to be considered for these awards should complete the financial need section on the regular University of Toronto admission awards application form.

JAMES L. MORRIS MEMORIAL PRIZE

The James L. Morris Memorial Prize is the gift of Mrs. J. H. Craig and Mr. J. R. Morris, K.C., in memory of their father, James L. Morris, C.E., O.L.S., D.Eng., the first graduate of the School of Practical Science, who died in 1946 after a distinguished career. Graduating in Civil Engineering in 1881 as the sole member of his class, Dr. Morris engaged in railway work for some time, first as an engineer and then as a contractor. For 43 years he conducted a successful civil engineering practice in Pembroke, Ontario, involving important undertakings in the field of municipal power and bridge work.

This Prize, of the value of the annual income from $3,000, is awarded annually to the student in the Second Year of the Course in Civil Engineering who obtains the highest aggregate percentage at the annual examinations of the First and Second Years of the course, provided always that the student obtains honour standing at the Examinations of the Second Year.

OTTO HOLDEN SCHOLARSHIP

Otto Holden, B.A.Sc., C.E., D.Eng., was a distinguished hydraulic engineer of international reputation. He served Ontario Hydro for 47 years and retired as Chief Engineer in 1960, having been involved in almost all of the major hydro-electric developments in Ontario. On his death Mr. Holden left a sum of money which was later augmented by his widow, the late Florence Holden, to establish a scholarship in the Faculty of Applied Science and Engineering. This scholarship, which has a value of approximately $750 is awarded to the student who, completing the Fourth Year in Civil Engineering or Mechanical Engineering with Honours, obtains the highest aggregate marks in hydraulic engineering subjects in the Third and Fourth Years of the course. The first award was made in the session 1967–68.

ONTARIO STUDENT AWARDS PROGRAM

All students who are attending eligible post-secondary institutions in Ontario may qualify for assistance under this Program provided that they satisfy the residence requirements as outlined in the Ontario Student Awards brochure and demonstrate financial need. An award under this Program will be made to the extent of established need in a combination of a non-repayable grant and a Canada Student Loan. Application forms and brochures for the 1972–73 Program will be available early in May, 1972. They may be obtained from the University of Toronto, Office of Student Awards, and all other post-secondary institutions. Applications should be submitted *in person* at the institution which the student plans to attend.

THE ONTARIO HOCKEY ASSOCIATION WAR MEMORIAL SCHOLARSHIP

The Ontario Hockey Association War Memorial Scholarship, the gift of the Ontario Hockey Association, is to be awarded annually at the Grade XIII examination to an applicant whose father served overseas with the Canadian Forces in World War I.

The value of this scholarship is $100 in cash, with an allowance of the same amount on the tuition fee for each session.

In determining the award of the scholarship, the academic qualifications of the candidate shall be first taken into account, provided always that no candidate shall be eligible for an award who has not met all the conditions required by the University of candidates for admission scholarships generally; but *cœteris paribus*, the award shall be made to a student who is in proved need of assistance.

The award shall be made by the Senate of the University upon the report of a committee to be appointed by the Senate, upon which committee there shall be always one member of the Staff of the University who shall be deemed to be representative of the Association.

Application should be made to the Office of Student Awards on the regular scholarship application form not later than May 1.

PAULIN MEMORIAL SCHOLARSHIP

The Paulin Memorial Scholarship, provided through the generosity of the late Mr. Fred W. Paulin, a graduate of this Faculty in 1907, was established in memory of his brother, John Cameron Paulin, a student of this Faculty, who was fatally injured in 1906 during a football practice. The scholarship, which has the value of the income from a capital fund of $10,000, approximately $550 annually, is awarded to a student who obtains high standing in the work of the first year in the Faculty of Applied Science and Engineering.

PROCTER AND GAMBLE BURSARY PLAN

Procter and Gamble Bursaries, the gift of the Procter and Gamble Company of Canada, are awarded annually to students in all years. Applicants must have at least Second Class Honours or better in the final examinations of the preceding year and demonstrate financial need. Applications must be submitted to the Office of Student Awards on or before December 1.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO ADMISSION SCHOLARSHIP

The Ontario Professional Engineers Foundation for Education provides an admission scholarship of the value of $500. It is awarded to the candidate who obtains the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to the Council that his attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other Admission scholarship.

Application must be made to the Office of Student Awards before May 1.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO SCHOLARSHIPS

The Ontario Professional Engineers Foundation for Education offers scholarships of a value of $250 in each of the First, Second and Third Years in the Faculty of Applied Science and Engineering in any course, to the students who, taking Honours, obtain the highest standing in the work of their respective years.

These scholarships will not be awarded to students who hold other scholarships.

PROFESSIONAL ENGINEERS GOLD MEDAL

The Association of Professional Engineers of the Province of Ontario has established in the Faculty of Applied Science and Engineering an award in the form of a gold medal accompanied by a gift of technical books of an approximate value of $50. The award will be made to the student of the final undergraduate year in any course who, taking honours, obtains the highest weighted average percentage in the practical work and written examinations of the year.

RANSOM SCHOLARSHIP IN CHEMICAL ENGINEERING

The Ransom Scholarship in Chemical Engineering is presented by A. C. Ransom, Esq., of Toronto, for the purpose of encouraging and giving financial assistance to students who choose the field of Chemical Engineering. This donation, consisting of $5,000, provides for a perpetual scholarship of an annual amount such as will be derived from the income of this sum. The first award was made on the results of the annual examinations of 1938.

The scholarship will be awarded annually to the student registered in the Course in Chemical Engineering who obtains the highest aggregate percentage of marks in the examinations of the First Year. The scholarship will be paid to the winner only if he proceeds to take his Second Year in the Course in Chemical Engineering in the University of Toronto.

J. E. REID MEMORIAL PRIZE

This prize, established in 1967 in memory of the late Professor J. E. Reid, is awarded to the student in the Fourth Year of the course in Electrical Engineering who, graduating with honours, achieves the highest aggregate marks in the Fourth Year examinations in the subjects pertaining to electronic communication.

THE RHODES SCHOLARSHIPS

The Rhodes Trustees offer for award in the Province of Ontario two out of ten of the Rhodes Scholarships for Canadians, each of the value of £1,000 and tenable at Oxford University for a period of two years; in certain cases, a third year may be authorized.

Each candidate must be a British subject with at least five years domicile in Canada and unmarried; he must have passed his nineteenth but not twenty-fifth birthday on October 1 of the year *for* which he is elected; he must have completed the first year of his course at a Canadian university at the time of application.

A candidate may apply either for the province in which he has his private home or residence, or for the province in which he has taken his university course.

In that section of the will in which he defined the general type of scholar he desired, Mr. Rhodes mentioned four groups of qualities, the first two of which he considered most important.

(1) Literary and scholastic attainments;
(2) Qualities of manhood, truth, courage, devotion to duty, sympathy, kindliness, unselfishness, and fellowship;
(3) Exhibition of moral force of character and of instincts to lead and to take an interest in his fellows;
(4) Physical vigour, as shown by fondness for and success in outdoor sports.

Some definite quality of distinction, whether in intellect, character or personality, or in any combination of these, is the most important requirement. Financial need does not receive special consideration.

Forms of application and full information regarding these scholarships may be obtained from the Registrar, University of Toronto, or from J. L. Stewart, Esq., General Secretary for the Rhodes Scholarships in Canada, 14th floor, 320 Bay St., Toronto 1. Selection is made in December for the following year and all applications must reach the provincial secretary before November 15 annually.

R.C.E. MEMORIAL SCHOLARSHIP

The Memorial Fund Committee of the Royal Canadian Engineers has established the R.C.E. Memorial Scholarship of a value of $125, open to students who have successfully completed their second to last year in the Faculty of Applied Science and Engineering or the School of Architecture.

A candidate must be:

(*a*) a member in good standing of the Canadian Officers Training Corps and have successfully completed one summer season's training, or

(*b*) an ex-member of the Canadian Officers Training Corps who has successfully completed two years of C.O.T.C. Training and has transferred to the Canadian Army (Militia) or to the Canadian Army (Supplemental Reserve), or

(*c*) a member of the Canadian Army (Regular) attending University under the Regular Officers Training Plan.

Selection is made on the basis of academic standing and of qualities of leadership.

Application forms may be obtained from the Office of Student Awards.

REGULAR OFFICER TRAINING PLAN

Tenable in approved degree courses, this plan is available to Canadian citizens who undertake to serve in the armed forces for at least four years after graduation. Accepted candidates will receive tuition, a book allowance of $125 and a living allowance of $193 per month during the academic session.

Application should be made to the Canadian Forces Recruiting Centre, 25 St. Clair Avenue West, Toronto 7.

HELEN E. ROGERS ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of Helen E. Rogers open to students entering any degree course in the University. Preference is given to applicants from outside Ontario but failing such candidates awards may be made to qualified Ontario students. Recipients must have a standing satisfactory to the Committee of Award on first admission and may continue to enjoy the scholarship in the upper years provided they maintain first class standing. The value in each year is a minimum of $200 and a maximum of $1,500 dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards by May 1 on the regular admission scholarship application form.

DON SALT MEMORIAL SCHOLARSHIPS

In memory of Donald John Salt, a graduate of the Faculty of Applied Science and Engineering and a practising geophysicist, the Canadian Exploration Geophysical Society has provided two scholarships of the value of $500 which are open to students in the Third and Fourth Years of certain courses in the Faculty of Arts and Science, and in Geological Engineering and the Geophysics option of Engineering Science in the Faculty of Applied Science and Engineering.

The award is made on evidence of the interest and ability of the applicant in relation to the field of mining geophysics.

Application should be made either to the Chairman of the Department of Physics or the Chairman of the Department of Geology by March 1 in the calendar year in which the award is to be made.

ROSEDALE CHAPTER I.O.D.E. AWARD IN ENGINEERING SCIENCE

An award of $400 will be made annually to a student enrolled in the Third Year of the program in Engineering Science, on the basis of academic standing and financial need. Recipients must be Canadian citizens, but not necessarily residents of Ontario.

Application should be made to the Secretary of the Faculty on the regular in-course bursary application form not later than October 15.

FREDERICK W. SCHUMACHER SCHOLARSHIP

The Frederick W. Schumacher Scholarship has been awarded in the Faculty of Applied Science and Engineering and in the Faculty of Arts under a bequest of the late Frederick W. Schumacher. It has a value of the income from the fund. The scholar must (*a*) be enrolled in the Second, Third or Fourth years in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and (*b*) must have high academic standing.

Applications must be submitted to the Office of Student Awards not later than October 15.

"SECOND MILE ENGINEER" AWARD

The Class of 3T5, convinced that a successful engineer must not only be professionally competent but also constantly aware of his responsibilities to humanity, and inspired by an address of President William E. Wickenden of the Case School of Applied Science, Cleveland, called "The Second Mile," which was based on the text from the Sermon on the Mount, "whosoever shall compel thee to go one mile, go with him twain" has established the "Second Mile Engineer" award. It is the desire of the donors to encourage undergraduates to participate fully in extra-curricular activities and to recognize the true importance of the more liberal subjects of the curriculum with the ultimate objective, on entering the profession, of becoming worthy Second Mile Engineers. The award comprises a grant of $200, a suitably inscribed presentation piece and an illuminated scroll, and is presented to a student in his final year.

An eligible group is chosen from those who have taken a prominent part in the affairs of the Faculty, either as office holders or in athletics. In making the award consideration is given to academic standing, with special emphasis on the candidate's attainments in the cultural and humanistic-social studies.

Particulars are furnished each session by the Class of 1935.

THE SIMPSONS-SEARS LIMITED (NORTHERN ONTARIO) SCHOLARSHIPS

These scholarships, the gift of Simpsons-Sears Limited, are open only to students of the Copper Cliff High School, The Sudbury High and Technical Schools, the Sturgeon Falls High School, the North Bay Collegiate Institute and Vocational School, the Kapuskasing High School and all the Secondary Schools along the Ontario Northland Railway. A scholarship of the value of $100 is available for each of the schools mentioned and an additional sum of $50 will be given to the student who obtains the highest percentage of the nine papers of Grade XIII selected in accordance with the regulations.

No scholarship will be awarded unless the candidate is in actual attendance in one of the colleges or faculties of the University and maintains a uniformly high standard to the satisfaction of the donors of the scholarships.

Application for these scholarships must be sent not later than May 15, to the Principal, Algonquin Composite School, North Bay, from whom further information may be obtained regarding conditions of award.

WALLACE AWARD

SOCIETY OF AUTOMOTIVE ENGINEERS PRIZE

In memory of William Wallace, Professor of Mechanical Engineering, University of Toronto, the Ontario Society of Automotive Engineers offers an annual prize of the value of $100 to a student of the Fourth Year in any course whose thesis on a topic related to Automotive Engineering is considered by the Head of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory.

SOCIETY OF CHEMICAL INDUSTRY MERIT AWARD

The Society of Chemical Industry Merit Award is made annually by the Society to the student in Fourth Year in the Department of Chemical Engineering who obtains the highest weighted average of marks in the results of the annual examinations for the year. The award is a gold key.

THE MURRAY F. SOUTHCOTE SCHOLARSHIP

Established by friends of the late Murray F. Southcote, a graduate of this Faculty (Aeronautical Engineering, 1950) this scholarship, which has a value of $100, is awarded in recognition of high standing at the Annual Examinations of the Third Year, in any course in the Faculty.

The first award was made in the Session 1964–65.

WALTER STERLING ADMISSION SCHOLARSHIPS

Established in memory of Walter Sterling, these scholarships are open to students entering any first degree course at the University of Toronto. Recipients must obtain

First Class Honours standing on the nine Ontario Grade XIII papers required for admission, and may continue to enjoy the scholarships in each year of their course providing they maintain Honour standing. The value of the scholarship is from $200 to $1,500 annually, dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards on the regular scholarship application form. The statement of financial need should be completed if an award greater than $200 is desired.

C.H.E. STEWART BURSARIES

Under the provisions of the will of the late Mary Jones Stewart a sum of $10,000 was bequested to the University, the income of which is to be used to provide a number of bursaries in denominations of $50, $75 and $100 to students in the Third and Fourth Years of courses in the Faculty of Applied Science and Engineering, the awards to be made on the basis of financial need, scholastic ability and general character, with preference being given to students who are descendants of veterans of the First and Second World War. Applications should be submitted to the Secretary of the Faculty by October 15, on the regular in-course bursary application form.

EDITH TYRRELL MEMORIAL BURSARY

The Women's Association of the Mining Industry of Canada has presented this Bursary, having the value of $600, annually, commencing in 1939, and named in memory of their founder and first president, Mrs. Edith Tyrrell. A medal donated by Dr. Tyrrell accompanies this Bursary. The Bursary is awarded to a student entering the Third or Fourth Year in the Course of Metallurgy and Materials Science, or Geological Engineering; it may be awarded two years in succession to the same student, but will usually be awarded at the beginning of the Third Year. The award will be made by a special committee appointed by the Association on the following basis:

(*a*) In addition to mental capacity, the student must show leadership ability and give promise, through his activities, of becoming a worthwhile influence in the affairs of the profession and the community.

(*b*) While attention is given to scholastic ability, as evidenced by his academic standing, it is not the governing factor. He must, however, stand in the top quarter of his class.

(*c*) Special consideration is given to financial need.

Application must be made to the Secretary of the Faculty within one month of the opening of the academic year.

S. UBUKATA FUND

The S. Ubukata Fund for Japanese students was established to assist students from Japan proper to pursue a course of study at the University of Toronto. The fund provides grants of varying values on the basis of the information submitted by the applicants who:

(*a*) must be Japanese students from Japan proper;
(*b*) must register in the University of Toronto devoting full time to their studies;
(*c*) are able to satisfy admission requirements regarding English facility;
(*d*) are not holding other financial aid.

UNIVERSITY OF TORONTO ALUMNI ASSOCIATION WAR MEMORIAL SCHOLARSHIPS

Six scholarships are awarded annually by the University of Toronto Alumni Association to students entering first degree courses at the University of Toronto. The scholarships have a value of $500 annually, and are tenable for two years, providing satisfactory academic standing is maintained. They are awarded for general proficiency in Grade XIII, and in addition to academic performance the committee of award will take into consideration the candidate's relationship to active service in the Armed Forces of Canada, need of financial assistance, participation in extra-curricular activities and such other qualifications as may commend themselves to the committee. One scholarship will be available to a student whose home is not in the Province of Ontario.

Students resident in Ontario may apply on the general admission scholarship form which must be submitted to the Registrar of the University not later than May 1. Evidence of relationship to active service in the Armed Forces of Canada should be attached. Students resident outside Ontario may obtain the necessary forms from the Office of Student Awards, University of Toronto.

THE U.T.S. ENGINEERING SCHOLARSHIP

The U.T.S. Engineering Scholarship, the gift of R. A. Bryce, Esq., of the value of $250. The scholarship will be awarded by a committee of the Staff of the University of Toronto Schools to a student of the Schools who has completed the requirements for admission to and enrols in the Faculty of Applied Science and Engineering.

WALLBERG ADMISSION SCHOLARSHIPS

Six admission scholarships, each of a value of $1000 are awarded annually from the income from the Wallberg Bequest on the recommendation of the Council of the Faculty to the two candidates who obtain the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to Council that this attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other Admission scholarship.

Applications must be submitted to the Office of Student Awards on the prescribed form by May 1.

WALLBERG UNDERGRADUATE SCHOLARSHIPS

These scholarships, four in number, of the value of $500 each, derived from the Wallberg Bequest, are awarded annually; two to students ranking first and second respectively at the annual examinations of the First Year; one to the student ranking first at the annual examinations of the Second Year; and one to the student ranking first at the annual examinations of the Third Year.

Any holder of one of these scholarships may not hold other awards listed in the index with an asterisk. The awards were first made on the result of the annual examination of 1947.

W. S. WILSON MEDALS

These medals have been provided in recognition of the service to the Faculty of Applied Science and Engineering of its former Assistant Dean and Secretary, William Stewart Wilson.

A medal will be awarded to the student in each graduating course, who, attaining Honours, achieves the highest standing in the final year of his course.

The first awards were made in the Session 1962–63.

WILLIAM R. WORTHINGTON MEMORIAL SCHOLARSHIP

The William R. Worthington Memorial Scholarship, the gift of Miss Ida R. Worthington, in memory of her brother, William R. Worthington, DIP.(1904), B.A.SC.(1905), of the value of the income from a fund is awarded annually to the student of the Second Year in the course in Civil Engineering who ranks highest at the annual examinations of that year.

The first award was made at the examination for the Session 1954–55.

LOAN FUNDS

From the loan funds mentioned below, small loans can be made to students who are in urgent need of assistance. The funds are not large and the loans must accordingly be restricted, both in amount and number, and principally to students in the Third and Fourth Years.

Inquiries for loans from any of the following funds should be made at the office of the Secretary of the Faculty.

Engineering Society Loan Fund
Elizabeth Speller Memorial Fund
James W. Crocker Memorial Fund
Harry F. Bennett Educational Fund
S.A.E. – Canadian Section Loan Fund
Avro Aircraft Limited Engineering Loan Fund
The William Storrie Memorial Fund
3T6 Engineers Loan Association

4T0 Engineering Loan Fund
The Devonshire Loan Fund
Class of '09 Trust Fund
University of Toronto Alumni Loan Fund
Wallberg Memorial Loan Fund

CLASS OF 1936 LOAN ASSOCIATION

Members of the Class of 1936 have made arrangements to assist students in obtaining loans through regular banking facilities. Information may be obtained from the Secretary of the Faculty.

ENGINEERING SOCIETY LOAN FUND

In 1932 the Engineering Society repaid to the Board of Governors a series of annual grants which, over a period of years, had been made to the Society for special purposes. The Board of Governors, appreciating this action, set aside this sum, to be known as the Engineering Society Loan Fund, to provide loans to students of the Faculty of Applied Science and Engineering. The administration of the fund is carried out by a Committee appointed by the Board. The fund is not large, and only small loans can be made to relatively few students. Further inquiries should be made at the office of the Secretary of the Faculty.

ELIZABETH SPELLER MEMORIAL FUND

Through the generosity of Dr. F. N. Speller, of the Class of 1893, the "Elizabeth Speller Memorial Fund" has been established to provide loans for worthy students of the Third and Fourth Years of this Faculty. Applications for loans from this Fund should be made to the Secretary of the Faculty.

JAMES W. CROCKER MEMORIAL LOAN FUND

This fund was established by Mrs. William Crocker in memory of her son, James W. Crocker, a graduate in Mining Engineering in 1938, who was killed in an accident in a mine in the same year.

HARRY F. BENNETT EDUCATIONAL FUND

This fund was established by subscription from members of The Engineering Institute of Canada in memory of the late Harry F. Bennett, M.E.I.C., who for six years prior to his death in 1946 was chairman of the Institute's Committee on the Training and Welfare of the Young Engineer, and who accomplished so much in this field by untiring efforts.

One purpose of the fund is to make loans to deserving students who need financial assistance to enable them to study engineering sciences at university level, and who have proved themselves by successfully completing their first year in engineering or the equivalent.

Loans will be made largely on the basis of character and to men who seem likely to develop the high professional standards which are essential to leadership in engineering science. A student who has been aided by this fund should feel that high obligations are placed on him; obligations to the subscribers, to the trustees, and to those coming after him who in turn can receive help as his loan is repaid.

Application forms may be obtained at the Faculty Office. The regulations are simple and the application of any worthwhile student will be given immediate and careful attention.

SOCIETY OF AUTOMOTIVE ENGINEERS – CANADIAN SECTION LOAN FUND

The Society of Automotive Engineers – Canadian Section has established a loan fund of $1,200 in the Faculty of Applied Science and Engineering. Preference is given to students in good scholastic standing and engaged in studies relative to the automotive and aircraft industries, and to students in fourth, third and second years in that order. Particulars may be obtained from the Secretary of the Faculty.

AVRO AIRCRAFT LIMITED ENGINEERING LOAN FUND

Avro Aircraft Limited has established a Loan Fund of $3,000 to provide loans to engineering students requiring financial assistance. Application should be made to the Secretary of the Faculty.

THE WILLIAM STORRIE MEMORIAL FUND

The William Storrie Memorial Fund has been established by Mrs. William Storrie to provide loans to undergraduates in the course in Civil Engineering. Application should be made to the Secretary of the Faculty.

THE DEVONSHIRE LOAN FUND

This fund has been established by Graduates and friends of Devonshire House to assist students in the Residence. Application should be made to the Office of the Dean of Devonshire House.

CLASS OF '09 TRUST FUND

The Class of '09 on the 50th Anniversary of their graduation made a sum of money available in the Faculty for financial aid to undergraduates, with preference to Second Year students. Inquiry should be made to the Secretary of the Faculty.

THE UNIVERSITY OF TORONTO ALUMNI LOAN FUND

This fund comes from subscriptions received originally in 1919 and in succeeding years from graduates of the University and is administered by the University of Toronto Alumni Association.

Loans are available to undergraduate and graduate students enrolled in a full time course at the University, in second and subsequent years.

Particulars may be obtained from The University of Toronto Alumni Association, Alumni House, Willcocks Street, Toronto.

IX

Discipline

A SUMMARY OF THE REGULATIONS OF THE CAPUT CONCERNING STUDENT DISCIPLINE

1. Subject to the general regulations of the Caput of the University regarding jurisdiction in matters of discipline the Council of University College, the governing bodies of the Federated Universities and Affiliated Colleges, and the Councils of the Faculties, Schools, and Institutes have disciplinary jurisdiction over the conduct of all students registered in these Divisions of the University in all matters of local or internal concern to these Divisions. Jurisdiction over the conduct of students while in residence regardless of the Division of the University in which they are registered is vested in the body administering the residence.

2. Jurisdiction concerning conduct likely to affect the interests of the University as a whole is vested in the Caput.

3. The Students' Administrative Council will be supported in the proper performance of all its obligations and duties as provided in its Constitution.

4. Where the appropriate body exercising disciplinary jurisdiction has found that a student of the University has engaged in conduct prejudicial to the interests of the University, the Caput may, in its discretion, suspend or expel such student from the academic privileges of the University. Every decision of the Caput involving the expulsion of a student from the University requires confirmation of the Board of Governors.

5. Any student who interferes with the personal liberty of another or who subjects another student to indignity or personal violence may be considered by the Caput or any other body exercising disciplinary jurisdiction in the University to have committed a breach of discipline.

6. Initiation ceremonies involving physical violence, personal indignity, interference with personal liberty, or destruction of property, may be deemed a breach of discipline by the Caput or any other body exercising disciplinary jurisdiction in the University.

7. Without limiting the disciplinary powers vested in the respective bodies exercising disciplinary jurisdiction as set forth in sections 1–7, the following are cited as illustrations of conduct which, in the past, has been considered a breach of discipline prejudicial to the interests of the University:

(i) The organising of a parade on the streets of the city or the taking part in such a parade without permission of the authorities.

(ii) The destruction or defacing of University property, raids on Residences or other University buildings, and the breaking into University buildings.

(iii) Rowdy and other forms of behaviour, either on or off the Campus, of such an objectionable nature as to bring the University into public disrepute.

8. Student Clubs and Associations

(a) The constitution of every society or association of students in the University and all amendments to such constitutions require to be approved by the relevant University authorities. The giving of approval, and the responsibility for the programs of student societies and associations, shall rest as follows:

(i) With the authorities of the College, Faculty or School concerned where the membership of the student society or association is drawn from a single College, Faculty or School.

(ii) With the Board of Stewards of Hart House, where the student society or association is a Committee of Hart House and is controlled by the Board of Stewards of Hart House.

(iii) With the Caput, in the case of all other student societies and associations.

(b) No approval will be given by any of the authorities listed in (a) above to the constitution of any society or association of students if that constitution permits:

(i) Membership in the society or association to persons who are not students of the University, unless in the case of the societies listed in (a) (ii) above, where membership is open also to graduates of the University and members of the Faculty of the University.

(ii) Any action of discrimination based upon race, religion, or colour.

9. The name of the University is not to be used in connection with a publication of any kind without permission of the Caput.

X Professores Emeriti

PROFESSORES EMERITI

E. A. Allcut, M.SC.(BIRM.), M.E., F.R.AE.S.,
Professor Emeritus of Mechanical Engineering

W. B. Dunbar, B.A.SC.,
Professor Emeritus of Engineering Drawing

C. E. Helwig, M.A.SC.,
Professor Emeritus of Civil Engineering

P. B. Hughes, B.SC.(MCG.), D.ENG.(EMBRY RIDDLE)
Professor Emeritus of Mechanical Engineering

K. B. Jackson, B.A.SC., D.SC.(WATERLOO),
Professor Emeritus of Applied Physics

G. R. Lord, B.A.SC., S.M.(M.I.T.), PH.D.
Professor Emeritus of Mechanical Engineering

O. J. Marshall, B.A.SC., C.E., O.L.S.,
Professor Emeritus of Civil Engineering

W. G. McIntosh, B.A.SC.,
Professor Emeritus of Mechanical Engineering

J. W. Melson, B.A.SC.,
Professor Emeritus of Surveying and Geodesy

C. F. Morrison, B.E.(SASK.), M.SC.(MCG.),
Professor Emeritus of Civil Engineering

L. M. Pidgeon, M.B.E., B.SC.(OXON.), PH.D.(MCG.), F.R.S.C.,
Professor Emeritus of Metallurgical Engineering

E. A. Smith, M.A.(MCM.),
Professor Emeritus of Chemical Engineering

G. F. Tracy, B.A.SC., S.M.(M.I.T.),
Professor Emeritus of Electrical Engineering

A. Wardell, B.A.SC.,
Professor Emeritus of Engineering Drawing

W. J. T. Wright, M.B.E., B.A.SC., B.A.,
Professor Emeritus of Engineering Drawing

XI Administrative Officers

1971–72

THE UNIVERSITY

Acting President: J. H. Sword, M.A., LL.D.
Assistant to the President: N. S. C. Dickinson, C.D., B.A.

Acting Executive Vice-President (Academic) and Provost: D. F. Forster, B.A., A.M.
Vice-Provost (Research Administration): Miss S. Dymond, B.A., Q.C.

Executive Vice-President (Non-Academic): A. G. Rankin, B.COM., F.C.A.
Executive Assistant to the Executive Vice-President (Non-Academic): J. F. Brook
Vice-President (Administration): F. R. Stone, B.COM., F.C.A.
Secretary of the Board of Governors: D. S. Claringbold
Director of Administrative Services: M. A. Malcolm, B.A.
Director of Physical Plant (to December 31, 1971): F. J. Hastie, B.SC., P.ENG.
(from January 1, 1972): J. T. Turner, B.SC., P.ENG.

Vice-President (Health Sciences): J. D. Hamilton, M.D., F.R.C.P.(C), D.SC.

Vice-President and Registrar, and Secretary of the Senate: R. Ross, M.B.E., M.A.
Assistant Registrar: Miss H. L. Reimer, B.A., B.PED.

Chief Librarian: R. H. Blackburn, M.A., B.L.S., M.S., LL.D.

Acting Director of University Extension: E. M. Gruetzner, B.A.

Assistant Registrar and Director of Admissions: W. Kent, M.A.
Director of Student Awards: P. S. Phillips, B.A., C.A.
Secondary School Liaison Officer: W. A. Hill
Director of Statistics and Records: J. M. Tusiewicz, B.SC.(ENG.), M.A.SC., M.B.A.
Director of University Health Service:
G. E. Wodehouse, M.C., M.D., F.R.C.P.(C), M.R.C.P.

Assistant Director of University Health Service (Women):
Miss F. H. Stewart, B.A., M.D.
Director of Career Counselling and Placement Centre: D. Currey, B.A.SC.
Acting Director of International Student Centre: E. A. McKee, M.A.
Director of Advisory Bureau: D. J. McCulloch, B.A., M.D., D.PSYCH., F.R.C.P.(C)
Director of Housing Service: Mrs. M. G. Jaffary, B.A.

Director of University of Toronto Press: M. Jeanneret, B.A., LL.D.

Director of University News Bureau: K. S. Edey
Director of Alumni Affairs: J. W. Duncanson, B.A.
Director of Development: R. L. Jones

Warden of Hart House: E. A. Wilkinson, B.A.
Director of Athletics and Recreation (Men): A. D. White, B.A., M.ED.
Director of Physical and Health Education (Women): Miss A. Hewett, B.ED., P.E.

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The University of Toronto issues the following calendars and other publications concerning courses of instruction given by the University. Requests for calendars or information may be directed to the Office of Admissions of the University or to the Secretary of the particular Faculty, School or Institute.

ADMISSION INFORMATION:	Admission Awards Undergraduate Admission Handbook Undergraduate Admission Bulletin
APPLIED SCIENCE AND ENGINEERING:	Faculty of Applied Science and Engineering Engineering at Toronto – descriptive brochure
ARCHITECTURE:	Faculty of Architecture, Urban and Regional Planning and Landscape Architecture
ARTS AND SCIENCE:	Faculty of Arts and Science – St. George Campus Scarborough College Calendar Erindale College Calendar
BUSINESS:	School of Business – Graduate Programmes in Business Administration
CHILD STUDY:	Institute of Child Study, The College of Education
DENTISTRY:	Faculty of Dentistry Division of Postgraduate Dental Education Division of Dental Hygiene
EDUCATION:	The College of Education Bachelor of Education in Extension Graduate Degrees in Education*
EXTENSION:	Degree Programmes in Extension Diploma and Certificate Programmes in Extension Pre-University Courses Continuing Education Programme (Business and Engineering) Continuing Education Programme (Special Programmes)
FOOD SCIENCES:	Faculty of Food Sciences
FORESTRY:	Faculty of Forestry
GRADUATE STUDIES:	School of Graduate Studies
HYGIENE:	School of Hygiene
LAW:	Faculty of Law
LIBRARY SCIENCE:	School of Library Science
MEDICINE:	Faculty of Medicine, Medical Course Division of Rehabilitation Medicine Division of Postgraduate Medical Education
MUSIC:	Faculty of Music Royal Conservatory of Music Year Book
NURSING:	School of Nursing
PHARMACY:	Faculty of Pharmacy
PHYSICAL AND HEALTH EDUCATION:	School of Physical and Health Education
SOCIAL WORK:	School of Social Work

*Write to: Ontario Institute for Studies in Education, 252 Bloor Street West, Toronto 181, Ontario.

NOTES

NOTES

NOTES

University
of Toronto

Faculty of
Applied Science
and Engineering

Calendar 1973-1974

University of Toronto Press
1973

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January

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CALENDAR 1974

January

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February

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March

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April

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May

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June

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July

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August

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September

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October

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November

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December

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I

Calendar 1973-1974

FALL TERM, 1973

July 1	Sunday	Dominion Day. Buildings closed.
August 6	Monday	Civic Holiday. Buildings closed.
August 29	Wednesday	*Registration of First Year students, from 9:30 a.m. to 4:30 p.m.
August 30	Thursday	*Registration of Second Year students, from 9:30 a.m. to 12:00 noon. *Registration of Third Year students, from 2:00 p.m. to 4:30 p.m.
August 31	Friday	*Registration of Fourth Year students, from 9:30 a.m. to 12:00 noon. *Students residing outside Metropolitan Toronto may register on Tuesday, September 4, 1973, without penalty.
September 3	Monday	Labour Day. Buildings closed.
September 4	Tuesday	Orientation program for First Year students.
September 5	Wednesday	Lectures and laboratory work commence at 9:00 a.m.
September 21	Friday	Last day for students to add or substitute courses.
October 8	Monday	Thanksgiving Day. Buildings closed.
October 19	Friday	Last day for students to drop a course without academic penalty.
November 9	Friday	Last date for withdrawal from the Fall Term without academic penalty.
December 7	Friday	Last day of lectures in Fall Term. All term work should be submitted by this date.
December 10	Monday	
to		
December 21	Friday	Study and examinations in Fall Term courses.
December 25	Tuesday	Christmas Day. Buildings closed.

SPRING TERM, 1974

January 1	Tuesday	New Year's Day. Buildings closed.
January 7	Monday	Students of all years report at the Galbraith Building to confirm their enrolment for the Spring Term.
January 8	Tuesday	Lectures and laboratory work commence at 9:00 a.m.
January 18	Friday	Last day for students to add or substitute Spring Term courses.
February 22	Friday	Last day for students to drop a Spring Term course without academic penalty.
March 15	Friday	Last date for students to withdraw from the Spring Term without academic penalty.
April 11	Thursday	Last day of lectures in Spring Term. All term work should be submitted by this date.
April 12	Friday	Good Friday. Buildings closed.
April 15 to April 26	Monday Friday	Study and examinations in Spring Term courses.

II

The Faculty of Applied Science and Engineering

ADMINISTRATIVE STAFF

Dean: B. Etkin, B.A.SC., M.A.SC., D.ENG., F.R.S.C.
Associate Deans: P. E. Burke, B.E. (N. S. TECH.), M.A.SC.
G. B. Craig, M.A.SC., PH.D.
Executive Assistant and Secondary Schools Liaison Officer:
J. S. Hewitt, B.SC. (QU.), M.SC., PH.D. (BIRM.)
Assistant Dean and Secretary: J. A. Gow, B.A.SC.
Assistant Secretary: W. J. Dowkes, B.A.SC.

The Faculty of Applied Science and Engineering in the University of Toronto offers the widest range of undergraduate and postgraduate studies in engineering in Canada. The four year Bachelor of Applied Science (B.A.Sc.) undergraduate program is offered in Civil, Chemical, Electrical, Geological, Industrial and Mechanical Engineering, in Metallurgy and Materials Science and in Engineering Science. The Engineering Science program offers specific options in Aerospace, Chemical, Computer Science, Electrical, Geophysics, Materials Science, Nuclear and Thermal Power and Physics.

The Faculty offers, through the School of Graduate Studies, postgraduate programs for the Master of Applied Science (M.A.Sc.), the Master of Engineering (M.Eng.) and the Doctor of Philosophy (Ph.D.). Through the immense diversity of the resources of the University it is possible to do research in bio-engineering (engineering and medicine), in environmental engineering (urban planning and the control of pollution in air, water and land), in the history of techology, etc. This remarkable pattern of bridges linking the arts, sciences and professions in studies of man, his ideas and works adds a distinctive vitality and range to engineering at Toronto.

There are some 2100 undergraduate students and 600 postgraduate students. Undergraduates are taught not only by the staff of the Faculty but also by staff of University departments in Chemistry, Geology, Mathematics, Physics, English, History, Philosophy and Political Economy. On the staff of the Faculty alone there are some 180 professors.

From its historic beginnings in the School of Practical Science (S.P.S.) in the eighteen-seventies, the Faculty has grown since 1906 as an integral and senior part of the University. For students an important historical fact is that the Engineering Society, the student society of the Faculty, with is "Cannon" and "LGMB" band, is the oldest engineering organization of any formal kind in Canada.

The Faculty is located on the main campus in a rectangle bounded on the south by College Street, the west by St. George Street, the north by Convocation Hall and on the east by Taddle Creek Road where, in the days of Canadian Confederation there was indeed a creek so named.

The administrative offices are located in the southwest corner of the Galbraith Building at 35 St. George Street. Students and visitors may obtain information and assistance here.

SUMMARY OF STUDENTS IN ATTENDANCE — *Session 1972–73*

PROGRAM		1	3	4	5	6	7	8	9*	TOTAL
Year	I	117	79	30	120	63	107	12	23	551
	II	119	116	69	97	61	94	18	42	616
	III	76	103	65	63	62	86	21	32	508
	IV	63	71	58	70	50	92	15	12	431
TOTAL										2106
Special Students										2

*as of July 1, 1973, Program 9 becomes Program 2.

III

General Information Admission and Registration

ADMISSION REQUIREMENTS

1. Full details of the University of Toronto undergraduate admission requirements for 1974 are contained in the Undergraduate Admission Handbook 1974–75 available on request from the Office of Admissions, University of Toronto, Toronto, Ontario, Canada, M5S 1A3 and in all Ontario secondary schools. The 1973 requirements follow.

2. ONTARIO GRADE 13 GENERAL REQUIREMENTS:

Entrance to the First Year of the undergraduate courses is offered, depending upon the number of places available, to candidates from Ontario secondary schools who demonstrate good standing, based upon the following evidence:

1. Completion of secondary school studies, including a full program of academic work at the Grade 13 level.
2. A recommendation by the secondary school last attended regarding probable success in university studies.
3. A complete academic report for the three final years of secondary school.
4. Results of standardized tests offered by the Service for Admission to College and University.

The Grade 13 program should include Relations and Functions, Algebra, Calculus, Physics and Chemistry. Superior students, who have completed a full Grade 13, but whose programs do not include all of these subjects will also be considered.

In addition, candidates seeking admission to the program in Engineering Science should have excellent standing.

3. APPLICATION PROCEDURES

Candidates currently in Ontario Grade 13 should apply through their high school using the General Application Form.

Other candidates should write to the Office of Admissions for a questionnaire which they will be invited to fill out for preliminary consideration.

The closing date for the receipt of applications is June 1. Only in circumstances which the Committee on Admissions deems exceptional will a late application be considered.

4. STANDARDIZED TESTS

Candidates from Ontario secondary schools are expected to write the standardized tests offered by the Service for Admission to College and University. Candidates from educational jurisdictions outside Ontario may improve their competitive position by taking the aptitude and applicable achievement tests offered by the Service for Admission to College and University or the aptitude test offered by the College Entrance Examination Board. For information they should write to the Service for Admission to College and University, 151 Slater Street, Ottawa, Ontario, Canada, K1P 5N1, or to the College Entrance Examination Board, Box 592, Princeton, New Jersey 08540, U.S.A.

5. CANDIDATES OFFERING CERTIFICATES OTHER THAN ONTARIO GRADE 13:

The following certificates are usually accepted as equivalent to Ontario Grade 13 although individual subjects cannot always be equated. Candidates offering Senior Matriculation programs from provinces other than Ontario must offer from their final secondary school year a full program including mathematics, physics and chemistry.

Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Saskatchewan — Grade 12
Newfoundland — First Year Memorial University
Prince Edward Island — First Year University of Prince Edward Island
Quebec — C.E.G.E.P. I or equivalent

The following are also usually accepted as equivalent to Ontario Grade 13 although individual subjects cannot always be equated. Candidates applying for admission to the Faculty of Applied Science and Engineering should include Mathematics, Physics and Chemistry in their studies.

UNITED STATES, CENTRAL AND SOUTH AMERICA

First Year University standing (normally 30 semester hours) in acceptable subjects from an accredited institution. Excellent students with high school diploma and C.E.E.B. Advanced Placement examinations may be considered.

ENGLAND, WEST INDIES, EAST AND WEST AFRICA, HONG KONG

General Certificate of Education, Higher School Certificate or University of Hong Kong Matriculation Certificate showing either passes in five subjects of which at least two must be passed at advanced (or principal) level; or passes in four subjects of which at least three must be passed at advanced (or principal) level. In either case passes are required in Physics, Chemistry and an acceptable mathematics subject. At least two of these must be at advanced level.

EUROPE AND COMMONWEALTH

A Graduation (Maturity) certificate from final year of secondary school is required from most European and Commonwealth countries.

INDIA, PAKISTAN

Bachelor's degree with high standing.

JAPAN, KOREA, TAIWAN

First Year University standing in acceptable subjects from an accredited institution.

PHILIPPINES

Second Year University standing in acceptable subjects from an accredited institution.

6. ENGLISH FACILITY

In addition to meeting the academic requirements outlined above, candidates whose mother tongue is not English may be required to meet an appropriate standard in a recognized test of English facility such as the University of Michigan English Language Test, the Certificate of Proficiency in English issued by the Universities of Cambridge or Michigan, or the Test of English as a Foreign Language (T.O.E.F.L.). The University of Toronto is a sponsoring agency for the University of Michigan English Language Test and information about the test is sent to any applicant of whom it will be required.

7. MATURE STUDENTS (NON-MATRICULANTS)

For information regarding admission as a Mature Student, please consult the Office of Admissions.

8. EARLY ADMISSION

(Ontario Grade 13 students only)

Ontario Grade 13 students with good school records may be offered admission as early as May 18, 1973.

Students wishing to be considered for Early Admission should ensure that their applications are forwarded by their schools to the Ontario Universities' Application Centre not later than December 31, 1972.

9. CANDIDATES WHO HAVE PREVIOUSLY FAILED IN UNIVERSITY WORK

Candidates with a previous failure in university work may be considered individually on their merits; candidates with two previous failures are normally refused admission.

10. PROCEDURE FOR REGISTRATION

Detailed instructions concerning registration will be mailed to returning and newly admitted students before the beginning of each academic year.

11. UNIVERSITY HEALTH SERVICE

The University Health Service operates a medical clinic at 256 Huron Street, a psychiatric consultation service at 2 Bancroft Avenue, an Infirmary service at 42 St. George Street and an athletic injury Surgery in Hart House.

All students are urged to obtain medical and hospital insurance coverage through the Ontario Health Insurance Plan (OHIP).

COLLEGES

New College and Innis College are multi-faculty colleges established within the University of Toronto. It is possible, but not obligatory for students of the Faculty of Applied Science and Engineering to become members of these colleges. Application for membership is at the option of the student.

Students entering the First Year who are interested in becoming members of either college should indicate their choice in the space provided on the University's admission application form. A college fee of $15 for New College, $17 for Innis College is required upon acceptance.

The facilities of Innis College and New College are described below.

INNIS COLLEGE

Innis College was constituted on July 1, 1964, and admitted its first students in the following September. It is a multi-faculty college of the University of Toronto, and includes undergraduate students in all Faculties and Schools of the University.

A special feature is the Writing Laboratory. This service offers assistance to Innis College students in the skills and methods of writing essays and other academic reports. A staff of experienced teachers is available to give individual instruction.

The College has limited residential space available in houses on campus. Separate application for residence accommodation must be made directly to the Residence Co-ordinator of Innis College.

Students entering First Year will be invited to apply for membership after they have been accepted into their Faculty or School. Students entering the Second to Fourth Years who wish to join the College should obtain an application form from the Registrar, Innis College, University of Toronto.

NEW COLLEGE

New College is a multi-faculty co-educational college established in 1962; in addition to students from the Faculty of Arts and Science those from other Faculties and Schools are eligible for membership. This gives students from all divisions of the University the opportunity to participate in the activities of a college and to associate with students in other fields of study. Individual tutoring is provided for students in some subjects and the Writing Facility offers assistance in written English and French.

The new buildings centrally located on the west campus, provide academic, social and dining facilities for all members of the College and in addition accommodate nearly 300 male students and about 380 women students in residence.

Students applying for membership in the College who wish accommodation in the Residence must apply on the prescribed form which may be obtained from the Dean of Men or the Dean of Women, New College.

RESIDENCE ACCOMMODATION

DEVONSHIRE HOUSE

Devonshire House, the University Residence for Men, accepts students from all Faculties. The facilities of the residence include a reading library, common rooms, music practice room, kitchenettes, laundry room, television and games rooms. It does not have a dining hall. Members may take their meals at Hart House, New College, University College Women's Union or Howard Ferguson Hall, all located nearby.

Application forms may be obtained from the Secretary to the Dean, Devonshire House, University of Toronto, Toronto M5S 1A1. Application should be made as early as possible.

NEW COLLEGE

The residence facilities of New College, and the procedure for application, are described in the entry under Colleges, above.

OTHER COLLEGES

Each of the four Arts Colleges also maintains a residence into which some engineering students may be accepted. Further information may be obtained from the Dean of Women or the Dean of Men at University College, Victoria College, Trinity College or St. Michael's College.

HOUSING SERVICE

For the convenience of those students who are not able to find accommodation in the University and College residences, the University Housing Service maintains a listing of rooming houses, flats, apartments and homes. Information may be obtained by telephoning 928-2542.

Off-campus housing of this nature is not subject to University regulation. However every effort is taken to make the information on the accommodation as complete as possible and students are encouraged to assist in this effort by reporting on the quality of the accommodation that they have occupied.

CAMPUS CO-OPERATIVE RESIDENCE INCORPORATED offers residence and apartment accommodation for graduate and undergraduate students. Total occupancy is 300 in residence, half male, half female, and 50 in apartments. Meals are provided, and non-residents are invited to eat at the Co-op Dining Rooms. Since the University of Toronto has no official connection with Campus Co-operative Residence, Inc., inquiries should be addressed direct to Campus Co-operative Residence Incorporated, 395 Huron Street, Toronto, Ontario M5S 2G5.

MARRIED STUDENT APARTMENTS

Apartment accommodation for married students is provided by the Ontario Student Housing Corporation in buildings located in the Bloor-Yonge area. The apartments (bachelor, one-bedroom and two-bedroom units) are unfurnished except for refrigerators, stoves and window drapes. Tenancy is by lease and is restricted to married couples of whom one or other must be registered as a full-time student at the University of Toronto. Additional information and application forms may be obtained at the University Housing Service, 49 St. George Street.

TARTU COLLEGE

Tartu College, opened in 1969, offers accommodation to undergraduate and post-graduate students in 444 single rooms and 15 double rooms. Cooking facilities are provided for groups of six. The rate for single rooms is $98 per month and $75 per month in double rooms. The college is located on Bloor Street at Madison Avenue. Since the University has no official connection with the college, all enquiries should be addressed to the Reservations Office, Tartu College, 310 Bloor Street West, telephone 925-4747.

ST. ANDREW'S-UNIVERSITY DAY NURSERY

This day nursery, established and supported by the University of Toronto, the Graduate Students' Union and the Students' Administrative Council, provides pre-school education and day care facilities for children of University of Toronto students. Children aged two to five years are accepted.

The nursery, located at St. Andrew's United Church, 117 Bloor Street East, is well equipped and staffed and is licensed under the Day Nursery Act, Province of Ontario. It operates from 8:30 a.m. to 5:45 p.m. throughout the winter and summer academic sessions. Fees are reasonable, and noon meals and morning and afternoon snacks are provided.

Priority of enrolment is given to children of University students, although children of other members of the University community will be considered.

Information may be obtained from the nursery (telephone 921-7078) or from the School of Graduate Studies.

THE UNIVERSITY OF TORONTO CAREER COUNSELLING AND PLACEMENT CENTRE

The Placement Centre, located at 344 Bloor Street West, Fourth Floor, is open from 8:45 a.m. to 5 p.m., each week-day. The staff of the Centre maintain lists of part-time, permanent and summer employment opportunities in a wide variety of fields including the various branches of engineering. Engineering undergraduates are invited to drop in to discuss careers and employment problems.

Students looking for summer jobs should register at the Centre early in the academic term. This is important because job priorities are established on the basis of registration dates. Also, to be eligible for assistance under the Ontario Student Aid Plan, it is necessary for a student who has *not* obtained summer employment to have both registered at the Placement Centre and to have sought employment. The Centre will provide Students who comply with these regulations with a letter for use with his O.S.A.P. application.

Early registration is also advisable for the fourth year permanent employment interviews which are organized by the Centre each year in December. Early registrants are given first choice of available interview times.

Students are given an opportunity to explore a variety of careers at a lecture and discussion series regarding careers in industry, government, and the professions, presented by the Centre each year during the month of October. Watch the Varsity and Toike-Oike for specific career topics and dates.

HART HOUSE

All full-time University of Toronto students are members of Hart House. Membership covers a wide variety of activities including concerts, debates, poetry readings and art exhibitions. Students are welcome to use the many rooms as well as the Farm in the Caledon Hills. The House is open from 7:00 a.m. to midnight every day of the year.

Food services are available from 8:00 a.m. to 11:30 p.m.: full-course meals in the Great Hall, table-service in the fully-licensed Gallery Dining Room, a coffee-shop and Pub in the Arbor Room and Tuck Shop. For further information about Hart House phone 928-5361.

IV

Fees, Deposits and Expenses

FEES

1. Undergraduate students in the Faculty of Applied Science and Engineering must pay annual fees according to the schedule listed below. The total fee in each case is made up of the academic fee and incidental fees; all incidental fees are payable in the first term.

Students will receive by mail in August a fees form and instructions for the payment of fees. In order to avoid delay in registration at the opening of the session it is recommended that at least the first term instalment of fees be forwarded by return mail before the end of August.

Fees may be paid by certified cheque, money order or personal cheque payable to the University of Toronto in Canadian funds, and mailed to the Office of the Comptroller, University of Toronto, Toronto M5S 1A2.

2. Payment of at least the First Term instalment must be made before the opening day of the session. An admit-to-lectures card cannot be issued until the student has complied with this requirement.

3. The Second Term instalment of fees, if not already paid, is due on the opening day of the second term and must be paid not later than January 15. After this date a penalty will be imposed. All fees for the session must have been paid in full before the student can be admitted to the annual examinations.

4. Adjustment of fees for students who withdraw is made up to the twentieth week of the session.

5. Fees, residence dues and other charges set forth in this calendar are subject to change by the Governing Council.

SCHEDULE OF FEES

Men Academic Year	*Academic Fee	†Incidental Fees	Total Fee (if paid in one instalment)	First Term Instalment	Second Term Instalment
I–IV	$750	$76	$826	$538	$300

Women

I–V	$750	$63	$813	$525	$300

*The Academic Fee includes the following fees:
Tuition; Library and Laboratory Supply; Annual Examinations; Laboratory Fee; and Degree.

†These Incidental Fees include the following fees:
For men – Hart House; Students' Administrative Council; Athletic; Health Service; Engineering Society; Faculty Athletic Association.
For women -- Hart House; Students' Administrative Council; Athletic; Health Service; Engineering Society.

FEE FOR RE-CHECKING MARKS

A student who requests that his marks be re-checked must submit with his petition a fee of five dollars ($5) for each paper to be checked. The fee is refunded if an error is found.

FEE FOR TRANSCRIPTS

Transcripts of academic record are furnished by the Faculty Office on payment of a fee of $1 for a single copy plus 25 cents for each additional copy requested on the same order.

SPECIAL STUDENTS' FEES

The fee is $115 per course, payable to the Fees Department.

PENALTY FOR LATE REGISTRATION

Any student who registers after the last date for normal registration must petition for acceptance of his registration and is required to pay a late registration fee as follows:

If registering within 7 calendar days – $10
If registering after 7 calendar days – $20

PENALTY FOR LATE SUBMISSION OF PROGRAM DOCUMENTS

A student who fails to submit his pre-registration form or his examination application form by the prescribed date will be subject to a fine of $1 for each day beyond the deadline, to a maximum of $20.

SUMMARY OF STUDENTS' EXPENSES

The following approximate statement of expenses will give the student a general idea of the cost of obtaining an education in the Faculty of Applied Science and Engineering in the University of Toronto, exclusive of personal expenses:

1. Fees, see schedule page 16.	
2. Board and lodging, per week	$30 up
3. Books and instruments, per year	$150 to $175
4. Miscellaneous personal expenses	$300 up

V Programs and Degrees

UNDERGRADUATE PROGRAMS

The Faculty offers the following programs leading to the degree of Bachelor of Applied Science:

Civil Engineering (Program 1)
Geological Engineering (Program 2)
Mechanical Engineering (Program 3)
Industrial Engineering (Program 4)
Engineering Science (Program 5)
Chemical Engineering (Program 6)
Electrical Engineering (Program 7)
Metallurgy and Materials Science (Program 8)
Aerospace Engineering (offered as an option in Engineering Science. See page 81.)

The curricula of the various programs are set out in detail in Section VI. The regulations for standing and promotion are given in Section VII.

PART-TIME STUDY – DIVISION OF UNIVERSITY EXTENSION

The first two years of all engineering programs except Engineering Science are also offered through the Division of University Extension for students interested in part-time study. The first-year program is available in both day-time and evenings, the second year in day-time only. As there is no provision in the Division of University Extension for courses beyond the second year, students wishing to complete their studies for the degree must enter into full-time study in the regular courses in the Faculty of Applied Science and Engineering.

Information regarding the Extension Program may be obtained from the Degree Courses Section, Division of University Extension, 119 St. George Street, University of Toronto, Toronto M5S 1A1.

GRADUATE STUDY AND RESEARCH

Facilities are available in the Departments of the Faculty for postgraduate study and research leading to the degrees of Master of Engineering (M.Eng.), Master of Applied Science (M.A.Sc.), and Doctor of Philosophy (Ph.D.). For further information see the Calendar of the School of Graduate Studies.

SPECIAL STUDENTS

Persons desiring to enroll as Special Students (not proceeding to the degree) should consult the Secretary of the Faculty regarding admission requirements and the procedure for application.

INTERIM HIGH SCHOOL ASSISTANTS' CERTIFICATE TYPE A

Graduates of engineering programs may be admitted to Type A certificate courses at the College of Education, University of Toronto, if they submit official transcripts which indicate that they have sufficient academic credits.

Graduates of engineering programs who lack sufficient academic credits for admission to Type A courses at the College of Education may be eligible for admission to the Type B course and later for endorsement of the type B certificate.

Inquiries regarding admission to the Type B course should be addressed to the Registrar, the College of Education, University of Toronto. Inquiries regarding endorsement of Type B certificates or admission to Type A certificate courses should be addressed to the Director, Committee on Advanced Standing, the College of Education, University of Toronto.

ASSOCIATIONS OF PROFESSIONAL ENGINEERS

Graduation from the Faculty of Applied Science and Engineering leads to registration as a Professional Engineer in the various Associations of Professional Engineers throughout Canada.

VI Curriculum

The curriculum is based upon a term system in which all courses of instruction (with the exception of certain courses taken in the Faculty of Arts and Science) will be one term in duration. There are two terms in the annual session, each concluding with final examinations in the courses offered. With the exception of the First Year, for which there are special provisions, students will be evaluated for promotion at the end of each term.

The curriculum provides a good deal of latitude to the student in choosing his program of study. A regular program consists of a maximum of six courses per term with a total weight of 48 units; with the approval of the Chairman of his Department a student enrolled in the second or higher years may elect to reduce his load to a minimum of 40 units per term, or to increase it to a maximum of 60 units. First-year students may not take less than the normal load of 48 units per term.

On the following pages of this section the curriculum of each program is set forth in detail. A common curriculum for students in First Year (in First and Second Years in Engineering Science) forms a basis in the fundamental subjects prior to subsequent specialization in various engineering disciplines. The student is able to choose from a wide range of technical electives in the senior years, and in the Fourth Year, all programs contain a thesis, which provides the student with the opportunity to carry out original work in his chosen field of study.

As a guide to students in apportioning their time a weight factor is shown opposite each course of instruction. The weight factor represents the number of hours per week, including both scheduled class-room time and home work, that the average student is expected to devote to that course. This weight factor is also used in the computation of the student's weighted average in the work of the term.

The program and regulations regarding the courses of study and examination, contained in this Calendar, hold good for this academic year only, and the Faculty of Applied Science and Engineering does not bind itself to adhere for the whole period of a student's course to the conditions here laid down.

ELECTIVE COURSES

Elective courses fall into four categories, viz. Technical Electives; Non-Technical Electives (in First and Second Year); Open Electives (in Third Year) and Free Electives (in Fourth Year). In general, the student must not select elective courses which would involve excessive duplication of material previously covered elsewhere in his program. The following paragraphs provide further instructions on the selection of elective courses:

1. TECHNICAL ELECTIVES: These are specified in the prescription for the program in which the student is registered. In most cases the choice is restricted to a specified list of available technical electives. The availability of a particular elective course may depend on a sufficient number of students wishing to take it; in a few courses it may be necessary to limit the number of students enrolled.

2. NON-TECHNICAL ELECTIVES (First and Second Year): Each student in the First and Second Year must include in his program a Non-Technical Elective in each term. In general, acceptable non-technical electives have as their central theme the study of man as an individual or of man as a social being.

The student may select his Non-Technical Elective from either of the following groups of courses:

(a) *"In-House" Non-Technical Electives*

The following courses have been arranged specifically for students of the Faculty of Applied Science and Engineering, and have been scheduled in slots MW1 and TR12, so as to be available to all students. (For descriptions of these courses, see page 166.)

ECO 281	Economics
ENG 281F/S	Effective Writing
ENG 282F/S	Twentieth Century Literature
ENG 283F/S	Canadian Literature
ENG 284F/S	Varieties of Fiction
ENG 285F/S	Drama and Modern Theatre
ENG 286F/S	Literature and Science
ENG 287S	Special Studies in English
HPS 280F/S	History of Science and Technology
HPS 281F	History of Technology and Engineering up to the Industrial Revolution
HPS 282S	History of Technology and Engineering from the Industrial Revolution to the Present
HPS 283S	Technology, Engineering and Society
PHL 291F	Science and Society
PHL 292S	Science and Philosophy

(b) *Courses in the Faculty of Arts and Science*

Students desiring a broader choice in their non-technical electives may select courses from the following list of courses in the Faculty of Arts and Science (with the exceptions as noted). Students making this selection should bear in mind that some of these courses (viz. foreign languages) may be more demanding than the "in-House" courses.

Acceptable Arts and Science Courses (with exceptions as noted below). Courses listed in the calendar of the Faculty of Arts and Science under the following prefixes:

ANT
EAS
ECO
ENG
FAR
FRE
GER
GLL
GRH
GRK
HIS
HPS
INI
INL
INM
INT
INU
INV
INX
ISL
ITA
JAL
JAP
JAZ
JER
JES
JMC
LAT
LIN
MUS
NES
PHI
PHL
POL
PRT
PSY
REL
SIS
SLA
SOC
SPA

Note: (i) Courses coded 195 may not be taken for credit

(ii) A half-course given over two terms has a code letter Y, e.g. ITA 221Y

(iii) Students wishing to take courses at the 300 level and higher must obtain the approval of the teaching department offering the course.

List of Exceptions (courses bearing the above prefixes which are not acceptable as Non-Technical Electives)

ECO 220	Quantitative Methods in Economics
ECO 240F	Mathematical Approach to Macroeconomic Theory
ECO 241S	Mathematical Approach to Microeconomic Theory
ECO 332	Advanced Mathematical Economic Theory
INI 213	Independent Studies
MUS 343Y	Musical Acoustics
PHL 250F	Modern Symbolic Logic
PHL 250S	Modern Symbolic Logic
PHL 251S	Probability and Inductive Logic
PHL 313F	Games, Decisions and Social Choice
PHL 350S	Intermediate Logic
PHL 353S	Set Theory
PSY 209F	Physiological Psychology
PSY 315S	Introduction to Mathematical Psychology
PSY 319F	Physiology of Sensory Motor Behaviour
PSY 322	Physiological Psychology Laboratory
PSY 329S	Computer Applications to Psychology
SOC 201	Social Statistics
SOC 318	Advanced Research Methods

(c) *Other Courses*

The following courses are acceptable as non-technical electives:

LA 102 Land Process

3. OPEN ELECTIVES (Third Year only): In each term of the Third Year there is provision for an "Open Elective" which the student must fill. Courses acceptable as Open

Electives are (i) any course which is acceptable as a Non-Technical Elective as defined in section 2 above, or (ii) excluding courses offered by the Faculty of Applied Science and Engineering, any degree credit course listed in a current University of Toronto calendar, or of one of its constituent colleges, federated colleges, or federated universities. Students selecting courses in category (ii) must obtain the approval of the teaching department offering the course.

A student in the Third Year whose technical program involves 16 or more units per term taken outside the Faculty may be permitted to choose a course offered within the Faculty as his Open Elective.

4. FREE ELECTIVES (Fourth Year only): In each term of the Fourth Year there is provision for a "free elective" which the student must fill. Any degree credit course listed in a current University of Toronto calendar or in a calendar of one of its constituent colleges, federated colleges, or federated universities is acceptable as a free elective. Students selecting courses other than the "In-House" Non-Technical Electives must obtain the approval of the teaching department offering the course. If taken within the Faculty of Applied Science and Engineering, the free elective must be a course carrying a weight of at least 6 units per term.

BASIC SCIENCE COURSES

All programs in the Faculty (with the exception of Engineering Science) must contain at least one course designated as a basic science, which will normally be physics or chemistry offered by the Departments of Physics or Chemistry, respectively, in the Faculty of Arts and Science. Students who entered First Year in 1971–72 or later must take one such course in either the Second, Third or Fourth Years.

Some programs specify a basic science course as core material while others permit a choice. The courses presently available are listed below. More information can be obtained from the curriculum prescription for the program in which the student is registered.

Program 1,* 2C — PHY 282S Introduction to Modern Physics
Program 3 — PHY 480F Modern Physics
Program 7 — PHY 384F Thermodynamics and Statistical Mechanics
Programs 8, 2B — PHY 282F Introduction to Modern Physics
Program 2A — PHY 283F Basic Classical and Modern Physics
Programs 4, 6 Choose one of those courses listed above, or
    PHY 215F Geophysics
    PHY 332F Molecular Biophysics
    PHY 333S Cellular Biophysics
    CHM 324F Crystal Chemistry

*Students in Program 1 are permitted to replace PHY 282S by another basic science course.

There are also some full year courses available to students in the Second, Third or Fourth Years of Program 4 which may be selected to fulfil the requirements for the basic science courses and a technical, open or free elective at the same time. These courses can be selected by students in program 6 in the Third or Fourth Years to fulfil the requirements for the basic science course and an open or free elective. Such courses are:

CHM 220	Chemical Statics and Dynamics
CHM 240	Introductory Organic Chemistry
CHM 350Y	Instrumental Methods of Analysis
BCH 320	Introductory Biochemistry
BCH 321	Introductory Biochemistry
BIO 100	Principles of Biology
PHY 218	Applications of Physics in Medicine

First Year Studies

Chairman For First Year Studies:
P. E. Burke, B.E. (N.S. TECH.), M.A.SC.

Coordinating Staff:

W. Janischewskyi, M.A.SC., Department of Electrical Engineering
W. A. Miller, PH.D.(MCG.), Department of Metallurgy and Materials Science
M. R. Piggott, M.SC., PH.D.(LOND.), Department of Chemical Engineering
R. A. Ross, M.A., PH.D., Department of Mathematics
S. Sandler, M.A.SC., Department of Chemical Engineering
S. D. Scott, B.SC., M.SC., PH.D., Department of Geology
I. W. Smith, M.A.SC., Department of Mechanical Engineering
G. T. Will, M.A.SC., Department of Civil Engineering
C. A. Wrenshall, B.E.(SASK.), Department of Civil Engineering

FIRST YEAR STUDIES

The First Year program is designed to build a strong foundation in the basic disciplines which underlie the whole field of engineering. There are two first year curricula – Division A, the standard curriculum and Division B, the enriched curriculum for students intending to pursue the Engineering Science program. Admission to the Division B curriculum is granted only to students with better-than-average ability in mathematics and the sciences. Students undertaking this curriculum must maintain satisfactory term and year averages in their first year work in order to pursue the Engineering Science program in their second year. (See page 52.)

Students entering Division A must elect one of the following programs in which they expect to continue in second year – Civil Engineering, Geological Engineering, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Electrical Engineering, and Metallurgy & Materials Science. Subject to the availability of places, a student who successfully completes the First Year in Division A may request to transfer to any other program within that Division.

Students wishing to transfer to a different program at the end of first year should make application to the Secretary of the Faculty not later than July 15.

FIRST YEAR CURRICULUM — DIVISION A

Civil Engineering	Chemical Engineering
Geological Engineering	Electrical Engineering
Mechanical Engineering	Metallurgy and Materials Science
Industrial Engineering	

Term 1F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Computer Programming†	APS 100F/S	1	—	3	7
Chemistry	CHE 100F	3	3	1	12
Applied Mechanics	CIV 100F	3	—	2	10
Engineering Graphics†	CIV 135F/S	2	5	—	8
Calculus I	MAT 186F	2	—	2	6
Algebra I	MAT 188F	2	—	2	6
Non-technical Elective*					8
Term 1S					
Computer Programming†	APS 100F/S	1	—	3	7
Engineering Graphics†	CIV 135F/S	2	5	—	8
Electricity and Magnetism	ELE 121S	3	1	1	10
Calculus II	MAT 187S	2	—	2	7
Algebra II	MAT 189S	2	—	2	6
Non-Technical Elective*					8
△**and one of:**					
Engineering Design	APS 101S	2	1	1½	8
Chemical Engineering**	CHE 101S				8
Applied Physical Geology	GLG 180S	3	1½	—	8
Structure and Properties of Matter	MMS 100S	3	1½	—	8

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†One half of the students in Division A will take Computer Programming in Term 1F; the other half will take Engineering Graphics. The arrangement is reversed in Term 1S.

*Students will select one course each term from the list of Non-Technical Electives on page 21 of the Calendar, or from a list of courses available in the Faculty of Arts and Science.

△None of these technical electives shall be pre-requisite for any course given in a subsequent term.

**Students select three projects from a provided list, for which the contact times may vary from 3 hours of lectures to 7½ hours of laboratory weekly.

FIRST YEAR CURRICULUM — DIVISION B

Engineering Science

Term 1F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Mechanics (Statics)	CIV 101F	2	—	1	6
Chemistry	CHE 102F	3	3	1	10
Computer Programming	CSC 180F	2	2	—	6
Calculus I	MAT 194F	3	—	2	10
Elements of Physics I	PHY 180F	2	1½	1	9
Non-Technical Elective*					8
Term 1S					
Electricity	ELE 150S	3	—	—	8
Linear Algebra	MAT 185S	2	—	1	8
Calculus II	MAT 195S	2	—	1	7
Elements of Physics II	PHY 181S	2	1½	1	9
Non-Technical Elective*					8
△and one of:					
Engineering Design	APS 101S	2	1	1½	8
Chemical Engineering**	CHE 101S				8
Engineering Graphics	CIV 136S	2	—	2½	8
Applied Physical Geology	GLG 180S	3	1½	—	8
Structure and Properties of Matter	MMS 100S	3	1½	—	8

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*Students will select one course each term from the list of Non-Technical Electives on page 21 of the Calendar, or from a list of courses available in the Faculty of Arts and Science.

△None of these technical electives shall be pre-requisite for any course given in a subsequent term.

**Students select three projects from a provided list, for which the contact times may vary from 3 hours of lectures to 7½ hours of laboratory weekly.

Civil Engineering

Professor and Chairman of the Department:
T. C. Kenney, B.ENG.(MC.G.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.)

Associate Professor and Associate Chairman of the Department:
K. A. Selby, B.A.SC., M.B.A., PH.D.(ILL.)

Professors:
F. A. DeLory, B.ENG.(MC.G.), M.A.SC., D.I.C.(IMP.), PH.D.(LOND.)
C. Hershfield, B.SC., C.E.(MAN.), M.A.SC.
M. W. Huggins, B.A.SC., M.A.SC.
P. H. Jones, B.A.SC., M.S.(NORTHWEST.), PH.D.(NORTHWEST.)
R. H. Mills, B.SC.(WITWATERSRAND)
H. R. Rice, B.SC.(QU.)
J. Schwaighofer, DIP. ING.(GRAZ.), M.S.(PENN. ST.), PH.D.(PENN. ST.), DR. TECH.(GRAZ.)
R. M. Soberman, B.SC.(DALH.), PH.D.(M.I.T.)
C. A. Wrenshall, B.E.(SASK.)

Associate Professors:
J. D. Barber, B.A.SC., M.A.SC.
A. P. Bernhart, DIP. ING.(GRAZ.), DR.TECH.(GRAZ.)
M. P. Collins, B.E.(CANTERBURY), PH.D.(N.S.W.)
R. A. Collins, B.A.SC., M.S.(ILL.), PH.D.(ILL.)
A. C. Davidson, B.SC., C.E., B.SC., E.E.(MAN.), M.A.SC.
M. M. Davis, B.SC.(QU.), M.SC.(PURDUE)
H. R. Frizzle, B.SC., E.E.(N.S.TECH.)
E. Hauer, B.SC., M.SC.(TECHNION), PH.D.(CALIF.)
J. Ganczarzyk, M.SC., D.SC.(GLIWICE), D.SC.(WARSAW)
B. J. Haynes, B.A.SC.
G. W. Heinke, B.A.SC., M.A.SC., PH.D.(MCM.)
H. L. Macklin, B.A.SC.

V. R. Riley, B.A.SC., PH.D.(CANTAB.)
E. I. Robinsky, B.A.(BEIRUT), B.SC.(BEIRUT), M.S.(HARVARD), PH.D.
G. N. Steuart, B.SC.(SASK.), M.SC.(CALIF.), PH.D.(CALIF.)
J. Timusk, B.A.SC., M.A.SC., PH.D.(LOND.)
S. M. Uzumeri, B.A.SC., M.A.SC.
J. Vlcek, B.SC.F.(N.B.), M.A.SC., D.SC.(BRATISLAVA)
P. M. Wright, B.E., M.SC.(SASK.), PH.D.(COLO.)

Assistant Professors:
P. C. Birkemoe, B.SC.E., M.S.(PURDUE), PH.D.(ILL.)
R. C. Gunn, B.A.SC., M.A.SC., M.SC.(OHIO STATE)
K. Meipoom, B.A.SC., M.A.SC.
G. K. Rodgers, B.A.SC., M.A.SC.(U.B.C.), PH.D.
G. T. Will, B.A.SC., M.A.SC.

Lecturers:
V. P. Borecky, DIP. ING.(PRAGUE), M.A.
R. G. Rice, B.A.SC., M.SC.(M.I.T.)

Special Lecturers:
A. R. M. Fam, B.ENG.(CAIRO), M.ENG.(MCG)
R. G. Foster, M.A.SC.
W. R. McDougall, B.A.SC.
M. G. Michail, B.A.SC.(AIN SHAMS), M.A.SC., PH.D.(WINDSOR)
T. Obiaga, B.SC.(IBADEN), M.A.SC., PH.D.

CIVIL ENGINEERING

Program 1

Civil Engineering as a profession is concerned with improving man's environment through the planning, designing and construction of facilities such as dams, buildings, transportation systems and municipal services. These activities encompass a very wide range of knowledge and this in turn creates special curriculum problems.

The program in Civil Engineering is arranged so that a student may undertake either a relatively broad study of the discipline or a more comprehensive examination of one of its principal fields (structural, municipal and sanitary, transportation, geotechnical, and surveying). This flexibility is derived from the fact that a fourth year student's program consists mainly of elective courses and a thesis. The departmental electives are timetabled so as to maximize the freedom of students to take the electives of their choice. Several project-oriented courses in the second year program provide students with an understanding of the engineering approach to planning and design.

In summary, the program is designed to develop well-informed creative engineers possessing innovative and directive capabilities.

SECOND YEAR CIVIL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Strength of Materials	CIV 210F	3	—	1	8
Surveying	CIV 255F	3	2	1	9
Computer Programming	CIV 260F	2	—	2	8
The Engineer and his Environment	CIV 267F	2	2	2	8
Calculus	MAT 280F	3	—	2	9
Non-technical Elective					8
Term 2S					
Engineering Materials	CIV 209S	4	2	1	10
Mechanics and Design of Structures	CIV 211S	4	—	2	10
Environmental Systems	CIV 240S	2	—	—	5
The Civil Engineer and his Profession	CIV 268S	2	2	2	8
Geology*	GLG 280S	2	1½	1	8
Non-technical Elective					8
Practical Experience	APS 299	—	—	—	—

*Students who have taken GLG 180S in First Year must replace GLG 280S by a Basic Science elective, normally PHY 282S (see page 23). Students who have not taken GLG 180S must replace one technical elective in the Third or Fourth Years by a Basic Science elective.

THIRD YEAR CIVIL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Design of Structures II	CIV 312F	3	—	2	9
Soil Mechanics	CIV 321F	2	1	—	6
Survey Camp*	CIV 358F	—	—	—	—
Engineering Mathematics	CIV 370F	3	—	2	8
Probability and Statistics	CIV 371F	2	—	2	7
Fluid Mechanics	MEC 351F	3	3	—	10
Open Elective					8

THIRD YEAR CIVIL ENGINEERING (CONTINUED)

Term 3S					
Design of Structures III	CIV 313S	3	—	2	10
Foundations	CIV 322S	2	1	1	7
Transportation Systems	CIV 330S	3	—	2	8
Municipal Engineering	CIV 340S	2	—	2	7
Technical Elective**		3		2	8
Open Elective					8

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*Survey Camp is taken prior to the commencement of regular courses in Third Year and the results included with those for the subsequent term on the basis of a weighting of 8 units.

**See list of Technical Electives on page 32.

FOURTH YEAR CIVIL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Administration and Management	CIV 475F	2	—	—	6
Technical Elective**		3		2	8
Technical Elective		3		2	8
Technical Elective		3		2	8
Technical Elective		3		2	8
Free Elective					8
Term 4S					
Public Speaking	CIV 474S	—	—	2	3
Thesis	CIV 499S	—	6	—	12
Technical Elective		3		2	8
Technical Elective		3		2	8
Technical Elective		3		2	8
Free Elective					8

***Technical Electives.* During Third and Fourth Year, students select eight technical electives. Each student is advised to consult with a member of the staff in establishing the electives in his program.

The technical electives offered by the Department of Civil Engineering are given below.

*Fall Term Electives***

CIV 405F	Advanced Strength of Materials
CIV 413F	Modular Construction
CIV 416F	Reinforced Concrete I
CIV 419F	Indeterminate Structures
CIV 421F	Foundations and Earthwork
CIV 429F	Air Photo Interpretation
CIV 430F	Traffic Engineering
CIV 431F	Transportation Planning
CIV 440F	Water Pollution Control Engineering
CIV 450F	Water Resources and Hydrology
CIV 455F	Photogrammetry and Remote Sensing
CIV 479F	Special Studies in Civil Engineering
CIV 498F	Thesis†

†With the permission of the Chairman of the Department, a student may elect to undertake a 20-unit thesis by taking both CIV 498F and CIV 499S.

Spring Term Electives

CIV 375S	*Engineering Economics and Decision Making
CIV 414S	*Advanced Engineering Materials
CIV 417S	Reinforced Concrete II
CIV 418S	Behaviour and Design of Steel Structures
CIV 420S	Construction Engineering
CIV 422S	*Engineering Geology
CIV 432S	Highway Engineering
CIV 439S	*Urban and Regional Planning
CIV 441S	Air Pollution Control Engineering
CIV 456S	*Engineering Applications of Surveying
CIV 457S	Control Surveys
CIV 479S	Special Studies in Civil Engineering
MEC 452S	Hydraulic Engineering

*Available to Third and Fourth Year students.

**With the approval of the Chairman of the Department a student may include, as part of his elective program, courses that are offered outside the Department provided that the University Department, Faculty or Institute offering the course has agreed to accept him for those courses.

Geological Engineering

The course in Geological Engineering is an interfaculty program for which the specialized core of geological study is provided by the Department of Geology (Faculty of Arts and Science) while several departments in the Faculty of Applied Science and Engineering, particularly the Department of Civil Engineering and the Department of Metallurgy and Materials Science contribute instruction in engineering subjects. The program is administered by a Course Committee whose members are:

D. W. Strangway, B.SC., PH.D., *Chairman; Professor and Chairman, Department of Geology.*
C. B. Alcock, B.SC., PH.D., A.R.C.S., D.SC.(LOND.), F.R.I.C., M.I.M.M., *Professor and Chairman, Department of Metallurgy and Materials Science.*
W. D. Baines, B.SC.(ALTA.), M.SC., PH.D.(IOWA), *Professor and Chairman, Department of Mechanical Engineering.*
J. B. Currie, B.A.(MCM.), M.A., PH.D., *Professor of Geology.*
W. F. Graydon, M.A.SC., PH.D.(MINN.), *Professor and Chairman, Department of Chemical Engineering.*
T. C. Kenney, B.ENG.(MCG.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.), *Professor and Chairman, Department of Civil Engineering.*
H. R. Rice, B.SC.(QUEEN'S), *Professor of Mining Engineering.*

GEOLOGICAL ENGINEERING

Program 2

Geological engineering is an interdisciplinary program that emphasizes engineering applications of earth science – geology, geophysics, geochemistry – to professional activities ranging from environmental engineering to exploration for energy and mineral resources. It is designed especially for students who wish to combine a study of earth science with cognate engineering disciplines such as civil or mineral engineering. Students entering the Second Year of the Program in Geological Engineering are offered a broad curriculum from which they can choose one of the following three options:

Option A, Mineral Exploration, provides a thorough grounding in basic geology including mineralogy, structure, petrology and stratigraphy. In addition it includes courses in Exploration Geochemistry and Geophysics, and in Mineral Deposits, Petroleum Geology and Groundwater Geology. Students can round out their education with courses in Mining and Mineral Processing, courses dealing with the properties of soils, or courses related to control of the environment.

Option B, Mineral Engineering, which is concerned with the concentration and processing of the valuable contents of the products of mining operations, emphasizes mineralogy in addition to basic physics and chemistry. Students will undertake specialized courses in the subject in the last two years of the Program.

Option C, Engineering Geology, represents the area relating Geology to Civil Engineering and Regional Planning. In the first two years students take a number of courses in basic geology and engineering. In later years they can choose from a wide range of courses which qualify them to identify and evaluate the "geological hazards" affecting the design and safety of specific engineering projects and to review regional planning proposals to reduce the destruction of our natural resources and the deterioration of our environment.

The three options have much in common in the Second Year and students may petition for a transfer from one option to another at the end of either Term 2F or Term 2S.

For the First Year curriculum see Division A, page 26.

SECOND YEAR GEOLOGICAL ENGINEERING†

Option A (Mineral Exploration)

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Inorganic Chemistry I	CHE 214F	2	—	—	7
Mineralogy	GLG 220	2	4	—	9
Calculus	MAT 280F	3	—	2	9
Basic Classical and Modern Physics	PHY 283F	3	—	—	8
Non-technical Elective					8
and one of:					
Strength of Materials	CIV 210F	3	—	1	8
Surveying#	CIV 255F	3	2	1	9
Engineer and his Environment	CIV 267F	2	2	2	8
Principles of Physical Geology*	GLG 120F	2	2	1	9

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†Students who intend to take GLG 321F in Third Year (Options A and C) must attend an 8-day field camp immediately following the Term 2S examinations at a cost of about $40 per student.

#Surveying, CIV 255F, is a prerequisite for Survey Camp, CIV 358F (see term 3F).

*This course is required of students who have not taken GLG 180S.

SECOND YEAR GEOLOGICAL ENGINEERING (CONTINUED)

		Lect.	Lab.	Tut.	Wt.
Term 2S					
Inorganic Chemistry II	CHE 215S	2	—	—	8
Principles of Historical Geology	GLG 122S	2	2	1	9
Mineralogy	GLG 220	2	4	—	9
Basic Electromagnetism	PHY 284S	1	3	—	7
Non-technical Elective					8
and one of:					
Geological Data Processing by Computer	GLG 221S	1	3	—	8
Probability and Statistics	STA 282S	2	—	2	8
Option B (Mineral Engineering)					
Term 2F					
Mineralogy	GLG 220	2	4	—	9
Calculus	MAT 293F	2	—	2	8
Physics and Chemistry of Materials	MMS 225F	4	—	3	9
Introduction to Modern Physics	PHY 282F	3	—	—	7
Non-technical Elective					8
and one of:					
Strength of Materials	CIV 210F	3	—	1	8
Surveying#	CIV 255F	3	2	1	9
Engineer and his Environment	CIV 267F	2	2	2	8
Principles of Physical Geology*	GLG 120F	2	2	1	9
Term 2S					
Principles of Historical Geology	GLG 122S	2	2	1	9
Mineralogy	GLG 220	2	4	—	9
Calculus and Differential Equations	MAT 294S	2	—	2	8
Physical Chemistry	MMS 203S	2	—	3	8
Inorganic Chemistry	MMS 226S	2	—	2	8
Non-technical Elective					8
Option C (Engineering Geology)					
Term 2F					
Strength of Materials	CIV 210F	3	—	1	8
Engineer and his Environment	CIV 267F	2	2	2	8
Mineralogy	GLG 220	2	4	—	9
Calculus	MAT 280F	3	—	2	9
Non-technical Elective					8

SECOND YEAR GEOLOGICAL ENGINEERING (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
and one of:					
Surveying#	CIV 255F	3	2	1	9
Principles of Physical Geology*	GLG 120F	2	2	1	9
Basic Science course**					
Term 2S					
Engineering Materials	CIV 209S	4	2	1	10
Environmental Systems	CIV 240S	2	—	—	5
Principles of Historical Geology	GLG 122S	2	2	1	9
Mineralogy	GLG 220	2	4	—	9
Non-technical Elective					8
and one of:					
Probability and Statistics	STA 282S	2	—	2	8
Basic Science course**					
Geological Data Processing by Computer	GLG 221S	1	3	—	8

#Surveying, CIV 255F, is a prerequisite for Survey Camp, CIV 358F (See term 3F).

*This course is required of students who have not taken GLG 180S.

**Students in Option C must use one of the technical electives in the Second, Third or Fourth Years for a basic science course, see page 23.

THIRD YEAR GEOLOGICAL ENGINEERING†

Option A (Mineral Exploration)

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Survey Camp (Optional)***	CIV 358F	—	—	—	—
Field Camp I##	GLG 325F	—	—	—	—
Petrology	GLG 320	2	3	—	8
Stratigraphy and Sedimentation	GLG 321F	1	3	—	8
Tectonics	GLG 322	1	3	—	8
Physical Geochemistry	GLG 324	3	—	—	8
Open Elective					8
and one of:					
Soil Mechanics	CIV 321F	2	1	—	6
Mining Technology I	CIV 328F	3	—	1	8
Air Photo Interpretation	CIV 429F	3	2	—	8
Geophysics	PHY 215F	2	—	1	8

THIRD YEAR GEOLOGICAL ENGINEERING (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
Term 3S					
Petrology	GLG 320	2	3	—	8
Tectonics	GLG 322	1	3	—	8
Physical Geochemistry	GLG 324	3	—	—	8
Geology of the Canadian Shield	GLG 327S	1	3	—	8
Open Elective					8
and one of:					
Foundations	CIV 322S	2	1	1	7
Mining Technology II	CIV 329S	2	—	2	8
Pleistocene Geology	CIV 327S	3	—	2	8
Probability and Statistics	STA 282S	2	—	2	8
Calculus and Differential Equations	MAT 294S	2	—	2	8
Introductory Metallurgy	MMS 224S	2	—	—	6
Option B (Mineral Engineering)					
Term 3F					
Survey Camp (Optional)***	CIV 358F	—	—	—	—
Petrology	GLG 320	2	3	—	8
Mining Technology I	CIV 328F	3	—	1	8
Mineral Processing I	MMS 301F	2	3	1	8
Physical Geochemistry	GLG 324	3	—	—	8
Open Elective					8
and one of:					
Mass Transfer Operations I	CHE 312F	2	—	2	9
Soil Mechanics	CIV 321F	2	1	—	6
Materials Science	MMS 222F	3	3	—	8
Term 3S					
Mining Technology II	CIV 329S	3	—	1	8
Petrology	GLG 320	2	3	—	8
Extractive Metallurgy I	MMS 305S	4	3	—	9
Mineral Processing II	MMS 412S	2	1½	—	7
Physical Geochemistry	GLG 324	3	—	—	8
Open Elective					8

THIRD YEAR GEOLOGICAL ENGINEERING (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
Option C (Engineering Geology)					
Term 3F					
Field Camp I##	GLG 325F	—	—	—	—
Survey Camp (Optional)***	CIV 358F	—	—	—	—
Soil Mechanics	CIV 321F	2	1	—	6
Stratigraphy and Sedimentation	GLG 321F	1	3	—	8
Tectonics	GLG 322	1	3	—	8
Fluid Mechanics	MEC 351F	3	3	—	10
Open Elective					8
and one of:					
Mining Technology I	CIV 328F	3	—	1	8
Petrology	GLG 320	2	3	—	8
Geophysics	PHY 215F	2	—	1	8
Term 3S					
Foundations	CIV 322S	2	1	1	7
Pleistocene Geology	CIV 327S	3	—	2	8
Tectonics	GLG 322	1	3	—	8
Geology of the Canadian Shield	GLG 327S	1	3	—	8
Open Elective					8
and one of:					
Mining Technology II	CIV 329S	3	—	1	8
Petrology	GLG 320	2	3	—	8
Calculus and Differential Equations	MAT 294S	2	—	2	8
Introductory Metallurgy	MMS 224S	2	—	—	6
Probability and Statistics	STA 282S	2	—	2	8

***Survey Camp is offered prior to the commencement of regular courses in Third Year. The results will be included with those for the subsequent term on the basis of a weighting of 8 units.

##Students who intend to continue in option A and C in their third year must attend Field Camp I, GLG 325F. This is an 8 day field camp in the Gaspe area immediately following term 2S examinations. Results for the camp will be included with those of the subsequent term on a basis of 6 units. A fee, currently about $45, is charged to cover part of the cost of transportation and accommodation.

†Students in options A and C must attend Field Camp II, GLG 425F. This is a 14 day field camp held in the Tweed area immediately following Term 3S examinations. Results for the field camp will be included with those of the subsequent term on a basis of 8 units. A fee, currently about $90.00, is charged to cover part of the cost of food and accommodation. Students in option B take first 7 days only at one-half regular fee.

FOURTH YEAR GEOLOGICAL ENGINEERING

Option A (Mineral Exploration)

		Lect.	*Lab.*	*Tut.*	*Wt.*
Term 4F					
Field Camp II	GLG 425F	—	—	—	—
Mineral Deposits	GLG 421	2	3	—	8
Exploration Geochemistry	GLG 422	2	3	—	8
Petroleum Geology	GLG 428F	2	3	—	8
Exploration Geophysics	PHY 338X	2	3	—	8
Free Elective					8
and one of:					
Soil Mechanics	CIV 321F	2	1	—	6
Mine Operation and Administration I	CIV 426F	2	—	3	8
Pollution Control Engineering	CIV 440F	3	—	2	8
Photogrammetry and Remote Sensing	CIV 455F	3	2	—	8
Term 4S					
Mineral Deposits	GLG 421	2	3	—	8
Exploration Geochemistry	GLG 422	2	3	—	8
Thesis	GLG 499S	—	6	—	8
Exploration Geophysics	PHY 338X	2	3	—	8
Free Elective					8
and one of:					
Mine Operation and Administration II	CIV 427S	2	—	3	8
Sedimentology	GGR 311S	1	1	—	6
Ground Water Geology	GLG 429S	2	3	—	8
Introductory Metallurgy	MMS 224S	2	—	—	6

Option B (Mineral Engineering)

		Lect.	*Lab.*	*Tut.*	*Wt.*
Term 4F					
Field Camp II	GLG 425F	—	—	—	—
Hydrometallurgy	MMS 413F	2	1½	1	8
Mineral Deposits	GLG 421	2	3	—	8
Mineral Engineering	MMS 414F	2	1½	1	8
Thesis	MMS 499	—	6	—	6
Free Elective					8

FOURTH YEAR GEOLOGICAL ENGINEERING (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
and one of:					
Chemical Reactors	CHE 432F	2	—	1	7
Mine Operation and Administration I	CIV 426F	2	—	3	8
Operational Research I	IND 301F	2	—	2	8
Term 4S					
Metallurgical Systems Analysis	MMS 407S	2	—	1	7
Mineral Deposits	GLG 421	2	3	—	8
Physics and Chemistry of Surfaces	MMS 415S	2	—	1	8
Thesis	MMS 499	—	12	—	12
Free Elective					8
and one of:					
Electrochemical Processes	MMS 404S	2	—	2	7
Environmental Engineering	CHE 423S	2	—	1	8
Mine Operation and Administration II	CIV 427S	2	—	3	8
Operational Research II	IND 302S	2	—	2	8

Option C (Engineering Geology)

Term 4F					
Field Camp II	GLG 425F	—	—	—	—
Subsurface Exploration	CIV 425F	3	2	—	8
Airphoto Interpretation	CIV 429F	3	2	—	8
Free Elective					
and three of:					
Surveying	CIV 255F	3	2	1	9
Rock Mechanics	CIV 424F	3	—	2	8
Mine Operation and Administration I	CIV 426F	2	—	3	8
Water Resources and Hydrology	CIV 450F	3	—	2	8
Photogrammetry and Remote Sensing	CIV 455F	3	2	—	8
Petroleum Geology	GLG 428F	2	3	—	8
Exploration Geophysics	PHY 338X	2	3	—	8
Term 4S					
Engineering Geology Seminar	CIV 423S	3	—	2	8
Sedimentology	GGR 311S	1	1	—	6
Thesis	CIV 496S	—	6	—	8
Free Elective					8

FOURTH YEAR GEOLOGICAL ENGINEERING (CONTINUED)

and two of:

Transportation Systems	CIV 330S	3	—	2	8
Construction Engineering	CIV 420S	3	—	2	8
Mine Operation and Administration II	CIV 427S	2	—	3	8
Geohydrology	CIV 449S	2	—	3	8
Hydraulic Engineering	MEC 452S	3	2	—	8
Exploration Geophysics	PHY 338X	2	3	—	8

Mechanical Engineering

STAFF OF THE DEPARTMENT

Professor and Chairman of the Department:
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G. E. Godfrey, M.A.SC.
D. McCammond, B.SC. (QU. BELFAST), PH.D. (QU. BELFAST)

Special Lecturer:
G. D. Ransford, B.A., B.C.E. (MELBOURNE), ING.D. (GRENOBLE)

MECHANICAL ENGINEERING

Program 3

Traditionally associated with the art and science of power generation and the machines and devices by which power is usefully applied and controlled, Mechanical Engineering, like other branches of the engineering profession, participates actively in the advancement of knowledge and interprets this knowledge in the design and development of practical systems.

In manufacturing industry, in the transportation and power utilities, in the high-performance field of air and space engineering, or in engineering aspects of major works and structures, the mechanical engineer finds professional occupation, either as employee or consultant. His responsibility will generally be for the superintendence of operations and personnel, for the design of products and processes, and may include the administration of enterprises.

The curriculum in Mechanical Engineering provides an analytical training in mathematics and the physical sciences designed as a disciplinary basis for active professional practice. Recognition is given, however, to the purer scientific and philosophical concepts essential to postgraduate study and research.

For the First Year curriculum see Division A, page 26.

SECOND YEAR MECHANICAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Engineering Law	APS 300F	1	—	—	2
Circuit Theory and Measurements	ELE 270F	3	1½	1½	10
Calculus	MAT 293F	2	—	2	8
Mechanics of Deformable Bodies I	MEC 211F	3	¾	2¼	10
Differential Equations	MEC 261F	3	—	3	10
Non-technical Elective					8

SECOND YEAR MECHANICAL ENGINEERING (CONTINUED)

		Lect.	Lab.	Tut.	Wt.
Term 2S					
Electromechanical Energy Conversion	ELE 272S	3	1½	1½	8
Dynamics I	MEC 201S	3	—	1½	8
Mechanics of Deformable Bodies II	MEC 212S	3	¼	1¼	8
Materials Science	MMS 223S	3	1½	—	8
Probability and Statistics	STA 282S	2	—	2	8
Non-technical Elective					8

THIRD YEAR MECHANICAL ENGINEERING

Term 3F		Lect.	Lab.	Tut.	Wt.
Thermodynamics	MEC 321F	3	1	2	10
Fluid Mechanics I	MEC 341F	3	2	1	10
Analysis and Design of Mechanisms	MEC 371F	3	—	3	10
Engineering Analysis I	MEC 362F	3	—	3	10
Open Elective					8
Term 3S					
Thermal Energy Conversion	MEC 322S	3	3	—	10
Vibrations	MEC 303S	3	1	2	10
Engineering Analysis II	MEC 363S	3	—	3	10
Technical Elective**					10
Open Elective					8

TECHNICAL ELECTIVES**

Term 3S					
Combustion Theory	MEC 323S	3	1½	—	10
Dynamics II	MEC 302S	3	—	1½	10
Elasticity	MEC 313S	3	—	1½	10
Fluid Mechanics II	MEC 342S	3	1½	—	10

**Technical electives offered in the terms 3S and 4S are equally available to 3rd and fourth year students. Third year students require the consent of the instructor if enrolling in a 4th year elective. With the approval of the Chairman of the Department, any other suitable course given by the Faculty of Applied Science and Engineering may be substituted as a Technical Elective. Departmental electives for which there is insufficient demand may be withdrawn.

FOURTH YEAR MECHANICAL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Physics	PHY 480F	3	—	1	9
Control Systems I*	MEC 455F	3	1½	1½	10
Heat and Mass Transfer*	MEC 431F	3	1½	1½	9
Thesis or Design Project	MEC 499	—	—	—	11
Technical Elective					10
Free Elective					8
Term 4S					
Design	MEC 472S	2	—	6	10
Applied Fluid Mechanics	MEC 443S	3	3	—	9
Heat and Mass Transfer*	MEC 431S	3	1½	1½	9
Control Systems I*	MEC 455S	3	1½	1½	10
Thesis or Design Project	MEC 499	—	—	—	3
Technical Elective**					10
Free Elective					8
TECHNICAL ELECTIVES					
Term 4F					
Thermal Power Generation	MEC 424F	3	1½	—	10
Computer-Aided Design	MEC 473F	3	—	1½	10
Thermal Environmental Design	MEC 420F	3	1½	—	10
Instrumentation Design	ELE 471F	3	1½	—	10
*Term 4S***					
Microscopic Thermodynamics	MEC 425S	3	1½	—	10
Manufacturing Analysis	MEC 475S	3	—	1½	10
Control Systems II	MEC 456S	3	—	1½	10
Numerical Analysis	CSC 481S	3	—	1½	10

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*Half of the students will take Control Systems I in the Fall Term and Heat and Mass Transfer in the Spring Term. The other half of the students will take the reciprocal arrangement.

**Technical electives offered in the terms 3S and 4S are equally available to 3rd and fourth year students. Third year students require the consent of the instructor if enrolling in a 4th year elective. With the approval of the Chairman of the Department, any other suitable course given by the Faculty of Applied Science and Engineering may be substituted as a Technical Elective. Departmental electives for which there is insufficient demand may be withdrawn.

Industrial Engineering

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P. J. Foley, M.A.(GLASGOW)
A. Kruger, B.A., PH.D.(M.I.T.)
A. Porter, M.SC.(MANCH.), PH.D.(MANCH.), F.R.S.C.

Visiting Professor:
J. W. Senders, A.B.(HARV.)

Associate Professors:
J. Abrham, M.A.(CHARLES), PH.D.(CHARLES)
J. A. Buzacott, B.SC.(SYDNEY), B.E.(SYDNEY), M.SC.(BIRMINGHAM), PH.D.(BIRMINGHAM)
S. H. Cohn, M.A.
T. A. Lambe, B.A.SC.(U.B.C.), M.SC.(STAN.), PH.D.(STAN.)
J. G. C. Templeton, B.A., A.M.(PRINC.), PH.D.(PRINC.)

Assistant Professors:
A. A. Cunningham, M.A.(OXFORD), PH.D.(ADELAIDE)
J. S. Rogers, B.SC.(DAL.), M.S.(STAN.), PH.D.(STAN.)
M. J. M. Posner, B.A.SC., PH.D.
I. B. Turksen, B.S.(PITTS.), M.S.(PITTS.), PH.D.(PITTS.)

Lecturers:
G. R. Comrie, B.A.SC.
E. E. Pickett, B.A.SC., M.A.

Special Lecturer (part-time):
J. Vanderheyden, B.A.SC.

INDUSTRIAL ENGINEERING

Program 4

The modern view of Industrial Engineering is that of a field concerned with the analysis, design, improvement and operation of integrated systems of men, materials and equipment. This concept crystallized when it became clear that certain modern technical fields, including operational research, control theory, computer science, probability and statistics, systems theory and human factors engineering, constituted a body of knowledge particularly useful in the operation and management of modern business, industry and government.

As a logical outcome of this development, the course in Industrial Engineering was established in 1958 to provide graduates in engineering specializing in the theory and practice of these subjects. This specialization rests upon a substantial foundation in science and mathematics, in fundamental engineering disciplines including fluid mechanics, applied thermodynamics, electric science, mechanics of materials, materials science and automation, and in such subjects as economics, organizational structure, financial control and the behavioural sciences.

The curriculum in Industrial Engineering allows, but does not require, each student to take a Technical Elective outside the Department in each term in each of Second, Third and Fourth Year.

Students choosing to take technical electives are urged to select them with care, in order to improve their general engineering education or their knowledge of an area in which they wish to specialize. A list of areas of concentration and corresponding recommended subjects is distributed to students in Industrial Engineering to assist them in their choice of technical electives.

The staff and fourth year students of the Department conduct a seminar series in the fall term. Also, the staff and third year students conduct a seminar series in the spring term. Although attendance is not required and no academic credit is given, these seminars are considered an important part of each student's engineering education. Members of the staff and invited speakers prominent in the academic, governmental and business communities conduct a series of talks followed by general discussion.

For the First Year Curriculum see Division A, page 26.

SECOND YEAR INDUSTRIAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Elements of Industrial Engineering I	IND 200F	2	—	2	8
Computers and Programming I	IND 202F	2	—	2	8
Calculus	MAT 293F	2	—	2	8
Probability	STA 291F	2	—	2	8
Non-technical Elective					
and one of:					
Materials Science	MMS 222F	3	3	—	8
Technical Elective*†					8
Term 2S					
Elements of Industrial Engineering II	IND 201S	2	—	2	8
Calculus and Differential Equations	MAT 294S	2	—	2	8
Statistics	STA 292S	2	—	2	8
Non-technical Elective					8
and two of:					
Mechanics of Materials	CIV 205S	2	3	—	8
Electrical Engineering	ELE 271S	3	1½	1	8
Technical Elective*†					

*Technical Electives are courses which satisfy one or more of the following criteria:

1. A technical course listed in the current calendar of the Faculty of Applied Science and Engineering with a weight not less than 7 units. Exclusion: Core courses in the Industrial Engineering program.
2. A course listed in the Faculty of Arts and Science calendar in one of the following subject areas: Mathematics, Computer Science, Astronomy, Physics, Chemistry, Biological Sciences, Geology.
3. A course which relates to one of the Department's areas of concentration. The list of permitted courses is available from the Department.

In each case, the Department has the right to exclude certain courses which involve excessive duplication of material with courses listed in the Department's program. Students should note that their acceptance in a course given by another Department may require approval by the Department.

†Basic Science Course. Students who entered First Year in 1971–72 or later are required to take one basic science course in either Second, Third or Fourth Year. A list of permissible basic science courses is given on page 23. This requirement can be met by using one of the six possible technical electives.

THIRD YEAR INDUSTRIAL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Numerical Methods I	CSC 381F	2	—	2	8
Accounting I	COM 390F	2	—	1	8
Operational Research I	IND 301F	2	—	2	8
Human Factors in Man-Machine Systems	IND 305F	2	3	—	8
Open Elective					8
and one of:					
Differential Equations	APM 391F	2	—	2	8
Industrial Relations	IND 304F	2	—	1	8
Technical Elective*†					8
Term 3S					
Operational Research II	IND 302S	2	—	2	8
Control Engineering	MEC 357S	2	1	1	8
Probability and Statistics	STA 392S	2	—	2	8
Computers and Programming II	IND 303S	2	—	2	8
Open Elective					8
and one of:					
Numerical Methods II	CSC 386S	2	—	2	8
Accounting II	COM 391S	2	—	1	8
Transport Phenomena	MEC 349S	3	1½	1½	8
Technical Elective*†					8

*See page 48 for note on Technical Electives.

†See page 23 for note on Basic Science Course.

FOURTH YEAR INDUSTRIAL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Free Elective					8
and five of:					
Organizational Behaviour	IND 412F	2	—	—	8
Fundamentals of Management Science	IND 413F	2	—	1½	8
Production Systems	IND 415F	2	—	1½	8
Stochastic Models	IND 417F	2	—	1½	8
System Simulation	IND 418F	2	—	1½	8
Management Information Systems	IND 421F	2	—	1½	8
The Psychobiology of Man-Machine Systems	IND 424F	2	3	—	8
Term Thesis#	IND 497F	—	6	—	8
Year Thesis#	IND 499	—	6	—	8
Technical Elective*†					8
Term 4S					
Free Elective					8
and five of:					
Applications of Management Science	IND 414S	2	—	1½	8
Advanced Industrial Engineering	IND 416S	2	—	1½	8
Information and Optimization	IND 419S	2	—	1½	8
Mathematical Programming	IND 420S	2	—	1½	8
Human Performance in Man-Machine Systems	IND 423S	2	3	—	8
Dynamics of General Systems	IND 425S	2	—	1½	8
Term Thesis#	IND 498S	—	6	—	8
Year Thesis#	IND 499	—	6	—	8
Technical Elective*†					8

#At least one of IND 497F, IND 498S and IND 499 must be selected. If IND 499 is selected, then neither IND 497F nor IND 498S may be selected.

*See page 48 for note on Technical Electives.

†See page 23 for note on Basic Science Course.

Engineering Science

FACULTY MEMBERS OF THE DIVISION

Chairman of the Division:
B. P. Stoicheff, B.A.SC., M.A., PH.D., F.R.S.C. (Professor of Physics)

Associate Chairman of the Division:
I. H. Rowe, M.A.SC., D.I.C.(IMP. COLL.), PH.D.(LOND.) (Associate Professor of Electrical Engineering)

Members of the Division:
R. L. Armstrong, M.A., PH.D. (Professor of Physics)
K. T. Aust, M.A.SC., PH.D. (Professor of Metallurgy and Materials Science)
G. F. D. Duff, M.A., PH.D., F.R.S.C. (Professor and Chairman of the Department of Mathematics)
I. I. Glass, B.A.SC., M.A.SC., PH.D. (Professor and Assistant Director – Education, Aerospace Studies)
F. C. Hooper, B.A.SC., D.I.C.(IMP. COLL.) (Professor of Mechanical Engineering)
J. J. Horning, M.S., PH.D. (Associate Professor of the Departments of Computer Science and Electrical Engineering)
I. H. Spinner, M.A.SC., PH.D. (Professor of Chemical Engineering)
G. F. West, B.A.SC., M.A., PH.D. (Professor of Physics)

ENGINEERING SCIENCE

Program 5

The Engineering Science program is designed for students whose primary interest is in the application of science to modern technology, and who wish to prepare themselves for careers in applied research, development or teaching. The undergraduate course provides excellent preparation for post-graduate work in a wide range of specialities in Engineering, Science and Mathematics, and the majority of graduates from this course do proceed to graduate study. Students who graduate from the course and do not continue their studies are nevertheless well qualified to fill a variety of positions in industry, government and teaching.

The courses offered are of a high standard, so that only students with better-than-average ability in, and aptitude for, mathematics and science can expect to succeed in them. For this reason, admission is granted only to those who have achieved high standing in their previous academic work, and continuation in the program requires a minimum of 55% at the end of the first term and 66% at the end of the second (see page 171). A student who does not meet these requirements will be permitted to transfer into another engineering program of his choice, subject to the requirements and provisions of the General Regulations. A student who successfully completes the First Year in Engineering Science may also transfer into any other program in the faculty. (Thereafter, transfers into other programs in the faculty can normally be made, subject to some program adjustments.)

The curricula for the first two years of the course are common for all students, with some technical electives available in terms 1S and 2S. There are available eight carefully planned *options*,† each of which provides a specialized preparation for a particular branch of applied science. In addition students have the opportunity not to enroll in any one of these options, but to take an *elective program*, as outlined below.

For the First Year curriculum see Division B, page 27.

SECOND YEAR ENGINEERING SCIENCE

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Numerical Methods	CSC 281F	2	—	1	7
Chemical Systems	CHE 209F	3	3	—	8½
Electric Circuits	ELE 250F	3	3	—	8½
Calculus III	MAT 295F	3	—	1	8
Physics III (Fields and Waves)	PHY 280F	3	1½	1	8
Non-technical Elective					8
Term 2S					
Complex Variables	MAT 289S	3	—	1	8
Physics IV (Quantum Physics)	PHY 281S	2	1½	1	8
Probability and Statistics	STA 287S	3	—	1	8
Non-technical Elective					8
two of:					
Engineering Design*	APS 201S	—	—	6	8
Mechanics of Materials	CIV 203S	2	—	3	8
Computer Languages	CSC 280S	2	—	1	8

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†For further information about the Aerospace Option, see page 81.

*This course will be limited to 20 students.

Students entering third year may elect

(a) to enrol in one of the 8 options listed, or

(b) to select a program that does not conform to any one of the options.

In case (a), students may petition for meritorious substitutions on a basis of roughly equal weights, so that the modified program has approximately the same weight as the standard option. In case (b), the weight shall average approximately 48 units per term. In both cases, the selection of courses is subject to the constraints imposed by the current timetable, and by prerequisites. Courses may be chosen from among those offered to other options in Engineering Science; from among those listed in the Faculty Calendar that are offered in programs other than Engineering Science; or, with the approval of the offering department, from among those offered in other Faculties, provided that the total applied science and engineering content is not reduced.

All electives and substitutions require the approval of the Division.

THIRD YEAR ENGINEERING SCIENCE

Option 5A, Aerospace

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations I	APM 393F	3	—	—	8
Mechanics	AER 301F	3	—	1½	8
Mechanics of Structures	AER 302F	3	—	1½	8
Aerospace Laboratory I	AER 303F	—	3	—	8
Technical Elective					8
Open Elective					8

Term 3S					
Algebra	MAT 390S	3	—	—	8
Aerospace Laboratory II	AER 304S	—	3	—	7
Fluid Mechanics	AER 305S	3	—	1½	8
Control Systems	ELE 358S	3	1½	1	9
Technical Elective					8
Open Elective					8

Option 5C, Chemical

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Mass Transfer Operations I	CHE 312F	2	—	2	9
Thermodynamics and Kinetics I	CHE 303F	2	3	—	9
Chemical Engineering Problems and Lab I	CHE 315F	—	2	—	7
Technical Elective					8
Open Elective					8

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Algebra	MAT 390S	3	—	—	8
Thermodynamics and Kinetics II	CHE 304S	2	3	—	9
Mass Transfer Operations II	CHE 313S	2	—	1½	8
Chemical Engineering Problems and Lab II	CHE 316S	—	2	—	7
Polymer Chemistry	CHE 317S	3	—	—	8
Open Elective					8

Option 5CS, Computer Science

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Physical Electronics I	ELE 350F	2	1½	—	7
Electronic Circuits I	ELE 351F	2	1½	—	8
Computer Organization	ELE 353F	3	1½	1	10
System and Signal Analysis I	ELE 355F	3	—	1	8
Open Elective					8
Term 3S					
Algebra	MAT 390S	3	—	—	8
Operational Research	IND 331S	2	—	2	7
Electronic Circuits II	ELE 360S	3	1½	—	8
Theory of Computation	CSC 364S	2	—	1	7
System Software I	CSC 380S	2	6	—	10
Open Elective					8

Option 5E, Electrical

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Physical Electronics I	ELE 350F	2	1½	—	7
Electronic Circuits I	ELE 351F	2	1½	—	8
System and Signal Analysis I	ELE 355F	3	—	1	8
Electromagnetic Fields	ELE 357F	3	1½	1	9
Open Elective					8
Term 3S					
Algebra	MAT 390S	3	—	—	8
Physical Electronics II	ELE 352S	2	1½	—	7
Electronic Circuits II	ELE 354S	3	3	—	10
System and Signal Analysis II	ELE 356S	3	1½	—	8
Open Elective					8

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
and one of:					
Quantum & Statistical Mechanics	PHY 382S	3	—	—	8
Digital Systems	ELE 314S	2	1½	—	6
Other Technical Elective					8
Option 5G, Geophysics					
Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Principles of Physical Geology	GLG 120F	2	2	1	9
Physics of the Earth	PHY 442	2	—	—	7
Electromagnetic Fields	ELE 357F	3	1½	1	9
Technical Elective*					8
Open Elective					8
Term 3S					
Algebra	MAT 390S	3	—	—	8
Principles of Historical Geology	GLG 122S	2	2	1	9
Physics of the Earth	PHY 442	2	—	—	7
Technical Elective*					8
Open Elective					8
and one of:					
Elasticity and Fluid Mechanics	PHY 244S	2	—	—	8
Quantum & Statistical Mechanics	PHY 382S	3	—	—	8
Option 5M, Materials Science					
Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Physical Metallurgy	MMS 303F	3	3	—	8
Metallurgical Thermodynamics	MMS 306F	3	—	4	9
Introduction to Solid State Physics	PHY 334F	2	—	—	8
Open Elective					8
and one of:					
Polymer Engineering	CHE 415F	2	—	1	7
Materials Science Laboratory	MMS 331F	—	3	1	7
Other Technical Elective					8

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*At least one of these technical electives must be a course offered by a Department of the Faculty of Applied Science and Engineering or by the Department of Geology. A list of recommended options is available from the Engineering Science Division Office or the Geophysics Laboratory.

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Algebra	MAT 390S	3	—	—	8
Physics of Metals	MMS 304S	3	3	—	8
Materials Science	MMS 307S	3	—	—	8
Technical Elective					8
Open Elective					8
and one of:					
Applied Nuclear Chemistry	CHE 418S	2	—	1	7
Applied Nuclear Physics	PHY 336S	2	1	—	8
Ceramics	CHE 420S	2	—	1	7
Composite Materials	CHE 413S	2	—	1	7

Option 5NT, Nuclear & Thermal Power

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Fluid Mechanics	MEC 354F	3	3	—	8
Microscopic Thermodynamics	MEC 425F	3	1½	—	10
Heat Engineering	MEC 327F	2	3	—	8
Introduction to Nuclear Physics	PHY 335F	2	—	—	8
Open Elective					8

Term 3S					
Algebra	MAT 390S	3	—	—	8
Quantum and Statistical Mechanics	PHY 382S	3	—	—	8
Control Systems	ELE 358S	3	1½	1	9
Experimental Stress Analysis	MEC 315S	2	1	1	8
Open Elective					8
and one of:					
Applied Nuclear Chemistry	CHE 418S	2	—	1	7
Applied Nuclear Physics	PHY 336S	2	1	—	8
Other Technical Elective					8

Option 5P, Physics

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Mechanics	AER 301F	3	—	1½	8
Modern Physics Laboratory	PHY 327F	—	6	—	10
Open Elective					8

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	Lab.	Tut.	Wt.
and one of:					
Physical Electronics I	ELE 350F	2	1½	—	7
Electronic Circuits I	ELE 351F	2	1½	—	8
Electromagnetic Fields	ELE 357F	3	1½	1	9
and one of:					
Molecular Biophysics	PHY 332F	2	—	—	8
Introduction to Solid State Physics	PHY 334F	2	—	—	8
Introduction to Nuclear Physics	PHY 335F	2	—	—	8
Term 3S					
Algebra	MAT 390S	3	—	—	8
Quantum and Statistical Mechanics	PHY 382S	3	—	—	8
Open Elective					8
and one of:					
Physical Electronics II	ELE 352S	2	1½	—	7
Experimental Stress Analysis	MEC 315S	2	1	1	8
Control Systems	ELE 358S	3	1½	1	9
and two of:					
Cellular Biophysics	PHY 333S	2	—	—	8
Applied Nuclear Physics	PHY 336S	2	1	—	8
Elementary Particle Physics	PHY 337S	2	—	—	8
Thermodynamics	PHY 353S	2	—	—	8

FOURTH YEAR ENGINEERING SCIENCE

Option 5A, Aerospace

Term 4F		Lect.	Lab.	Tut.	Wt.
Thesis	APS 495	—	—	—	8
Differential Equations II	APM 441F	3	—	—	8
Free Elective					8

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
and one of:					
Engineering Design I	AER 406F	—	3	—	8
Aerospace Laboratory III	AER 408F	—	6	—	8
*and a selection of courses from Groups A and B totalling approximately 16 units:					
Group A					
Aerodynamics	AER 401F	3	—	1½	9
Space Flight Dynamics	AER 402F	2	—	1½	8
Advanced Mechanics of Structures	AER 403F	2	—	1½	8
Group B					
Physics and Mechanics of Solids	AER 404F	3	—	1½	9
Fundamentals of Lasers, Plasmas and Energy	AER 415F	3	—	1½	9
Term 4S					
Thesis	APS 495	—	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8
Free Elective					8
and one of:					
Engineering Design II	AER 407S	—	3	—	7
Aerospace Laboratory IV	AER 409S	—	6	—	7
*and a selection of courses from Groups A and B totalling approximately 16 units:					
Group A					
Gasdynamics	AER 410S	3	—	1½	9
Stability and Control of Aircraft	AER 411S	3	—	1½	9
Aeroelasticity	AER 412S	2	—	1½	8
Group B					
Acoustic Theory and Noise Control	AER 414S	2	1½	—	8
Technical Elective					8

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*In the aggregate of terms 4F and 4S the student's program must include at least two courses from Group A. Courses in Groups A and B for which there is insufficient demand may be withdrawn.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	Lab.	Tut.	Wt.
Option 5C, Chemical					
Term 4F					
Thesis	APS 496	—	—	—	6
Differential Equations II	APM 441F	3	—	—	8
Rate Processes I	CHE 435F	3	—	—	9
Free Elective					8
and two of:					
Chemical Plant Design	CHE 406F	—	—	6	9
Strategy of Product and Process Development	CHE 409F	2	3	—	9
Chemical Engineering Project	CHE 441F	—	6	—	9
Optimal Control of Chemical Systems	CHE 437F	3	—	1½	9
Term 4S					
Thesis	APS 496	—	—	—	6
Applied Functional Analysis	APM 446S	3	—	—	8
Rate Processes II	CHE 436S	3	—	—	9
Free Elective					8
and two of:					
Topics in Applied Chemical Thermodynamics	CHE 404S	2	—	1	7
Selected Topics in Organic Chemistry	CHE 439S	3	—	—	9
Modelling and Simulation of Chemical Systems	CHE 440S	3	—	—	9
Option 5CS, Computer Science					
Term 4F					
Differential Equations II	APM 441F	3	—	—	8
System Software II	CSC 480F	2	6	—	10
System & Signal Analysis I	ELE 355F	3	—	1	8
Communication Systems I	ELE 453F	2	—	1	8
Operating Systems	CSC 468F	2	—	1	8
Free Elective					8

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Term 4S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thesis	APS 498S	—	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8
Computation Methods for Partial Differential Equations	CSC 446S	2	—	1	8
Techniques of Optimization	ELE 455S	3	—	1	8
Switching Circuits	ELE 432S	2	3	—	8
Free Elective					8

Option 5E, Electrical

Term 4F					
Differential Equations II	APM 441F	3	—	—	8
Free Elective					8
Select courses from the following to total approximately 48 units for the term:*					
Computer Organization	ELE 353F	3	1½	1	10
→ Network Theory [3]	ELE 412F	3	—	2	8
Semiconductor Physics	ELE 435F	2	1½	1	8
Computer Programming & Data Structure	ELE 440F	2	—	2	8
Techniques of System Theory	ELE 450F	2	1½	—	8
Electronic Circuits III	ELE 452F	2	3	—	8
Communication Systems I	ELE 453F	2	—	1	8
Switching Theory	ELE 459F	2	—	1	7
→ Fundamentals of Lasers, Plasmas and Energy	AER 415F	3	—	1½	9
Thesis[1]	APS 495	—	—	—	8
Other Technical Elective					8

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*Courses for which there is insufficient demand may be withdrawn.

[1] Select either APS 495 or APS 498S, but not both.

[3] Courses joined by arrows cannot be taken together because of timetable conflicts.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

	Term 4S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
	Applied Functional Analysis	APM 446S	3	—	—	8
	Free Elective					8
	Thesis[1]	APS 495	—	—	—	8
	Thesis[1]	APS 498S	—	—	—	8
	Select courses from the following to total approximately 48 units for the term, at least 16 units of which must be from Electrical Engineering:*					
3	→ Nuclear Reactors and Instruments	CHE 429S	2	1½	1	8
	→ Operational Research	IND 331S	2	—	2	7
	Integrated Circuits	ELE 431S	2	3	—	8
	Switching Circuits	ELE 432S	2	3	—	8
	→ Quantum Electronics	ELE 437S	3	1½	—	8
3	→ Techniques of Optimization	ELE 455S	3	—	1	8
	Computer Organization	ELE 441S	2	3	—	8
	→ Biomedical Engineering[2]	ELE 445S	3	1½	—	8
3	→ Power Semiconductor Circuits	ELE 433S	2	3	—	8
	→ Communication Systems II	ELE 454S	2	3	—	8
	Microwave Electronics	ELE 457S	2	1½	1	8
	Other Technical Elective					8

Option 5G, Geophysics

Term 4F					
Differential Equations II	APM 441F	3	—	—	8
Theory and Application of Geophysical Methods	PHY 443X	2	3	—	11
Time Series Analysis Laboratory	PHY 422F	—	6	—	8
Thesis	APS 499	—	—	—	5
Technical Elective**					8
Free Elective					8

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*Courses for which there is insufficient demand may be withdrawn.

[1] Select either APS 495 or APS 498S, but not both.

[2] Limited enrolment.

[3] Courses joined by arrows cannot be taken together because of timetable conflicts.

**At least one of the three technical electives must be a course offered by a Department of the Faculty of Applied Science and Engineering or by the Department of Geology. A list of recommended options is available from the Engineering Science Division Office or the Geophysics Laboratory.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Term 4S

Applied Functional Analysis	APM 446S	3	—	—	8
Theory and Application of Geophysical Methods	PHY 443X	2	3	—	11
Thesis	APS 499	—	—	—	5
Technical Elective I**					8
Technical Elective II**					8
Free Elective					8

Option 5M, Materials Science

Term 4F

Thesis	APS 495	—	—	—	8
Differential Equations II	APM 441F	3	—	—	8
Solid State Science	MMS 402F	3	3	1	9
Theory of Metallurgical Reactions	MMS 410F	2	—	2	8
Technical Elective					8
Free Elective					8

Term 4S

Thesis	APS 495	—	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8
Advanced Materials Science	MMS 411S	3	3	—	8
High Temperature Physical Chemistry	MMS 409S	2	—	2	8
Technical Elective					8
Free Elective					8

Option 5NT, Nuclear & Thermal Power

Term 4F

Differential Equations II	APM 441F	3	—	—	8
Nuclear Reactor Fundamentals	CHE 442F	3	3	—	11
Thermal Energy Conversion	MEC 428F	3	3	—	11
Thesis	APS 497	—	—	—	10
Free Elective					8

**At least one of the three technical electives must be a course offered by a Department of the Faculty of Applied Science and Engineering or by the Department of Geology. A list of recommended options is available from the Engineering Science Division Office or the Geophysics Laboratory.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Term 4S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Applied Functional Analysis	APM 446S	3	—	—	8
Neutron and Photon Transport	CHE 452S	3	—	2	10
Heat Transfer	MEC 433S	2	—	—	7
Thesis	APS 497	—	—	—	6
Technical Elective					8
Free Elective					8

Option 5P, Physics

Term 4F					
Differential Equations II	APM 441F	3	—	—	8
Technical Elective*					8
Free Elective					8
and three of:					
Quantum Physics Laboratory I	PHY 427F	—	6	—	8
Quantum Theory I	PHY 450C	2	—	—	8
Statistical Mechanics I	PHY 451C	2	—	—	8
Relativity Theory I	PHY 452C	2	—	—	8
Nuclear Physics I	PHY 453C	2	—	—	8
High Energy Physics I	PHY 454C	2	—	—	8
Solid State Physics I	PHY 455C	2	—	—	8
Modern Optics & Radiation I	PHY 456C	2	—	—	8
Group Theory and its Physical Applications I	PHY 457F	2	—	—	8

*Term 4S***					
Thesis	APS 498S	—	—	—	8
Technical Elective 1*					8
Technical Elective 2*					8

and choose 3 courses from the following, at least 1 from Group A:

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*These technical electives must all be courses offered by a department of the Faculty of Applied Science and Engineering.

**If the Free Elective chosen in the Fall Term is a full year course, the portion offered in the Spring Term may be used to replace one of the Spring Term Electives.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Group A

Quantum Theory II	PHY 450D	2	—	—	8
Statistical Mechanics II	PHY 451D	2	—	—	8
Relativity Theory II	PHY 452D	2	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8

Group B

Quantum Physics Laboratory II	PHY 428S	—	6	—	8
Nuclear Physics II	PHY 453D	2	—	—	8
High Energy Physics II	PHY 454D	2	—	—	8
Solid State Physics II	PHY 455D	2	—	—	8
Modern Optics & Radiation II	PHY 456D	2	—	—	8
Group Theory and its Physical Applications II	PHY 458S	2	—	—	8

Chemical Engineering and Applied Chemistry

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CHEMICAL ENGINEERING

Program 6

Undergraduate study in the Department of Chemical Engineering and Applied Chemistry is an excellent preparation for not only a career as a professional chemical engineer, but also for many careers in applied science. In recent years, many graduates from the Department have pursued such careers in addition to those entering the major chemical and petroleum industries.

The chemical engineer is concerned with the development and operation of processes by means of which matter is chemically altered to a more useful form, and in the design, construction, operation and management of plant in which to effect such changes. In addition to such obviously chemical processes as those encountered in the petroleum refining and petro-chemical industry, a great variety of industrial processes involve chemistry and require the abilities of the chemical engineer.

In order to equip a student to start his professional career as a chemical engineer, the undergraduate course is intended to provide him with training in the principles of the major divisions of chemistry and chemical engineering, together with the essentials of other engineering subjects. An important part of the course is the application of the principles to areas of major engineering interest.

Elective subjects available in the Department allow a particular emphasis to be achieved, for example, in one or more of the following areas: environmental chemistry and engineering, polymer science, wood chemistry, materials science, ceramics, medical engineering, analytical chemistry, fluid mechanics, nuclear power engineering, nuclear chemistry, biochemical engineering, optimal control, surface chemistry, combustion, pipeline transportation, separation processes and heat transfer. Specialist courses in other Departments or Faculties may also be selected, e.g. courses in biochemistry and microbiology for a program with a bio-chemical engineering emphasis. In this way, advantages may be taken of the resources within the University, and an individual student may arrange his program to suit his desires and career objectives.

In the final year, the topic chosen for the thesis allows the student additional specialization. The thesis serves as an introduction to research and the application of principles to topics of engineering interest, and its nature may vary widely depending on the interests of the staff and students. It may, for example, be concerned with an experimental laboratory investigation, the design of a process, or a computer study of a chemical system.

For the First Year curriculum see Division A, page 26.

SECOND YEAR CHEMICAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Physicochemical Principles in Chemical Engineering I	CHE 201F	2	—	—	5
Analytical Chemistry Laboratory*	CHE 203F				
Analytical Chemistry	CHE 204F	2	10½	—	14
Industrial Process Operations I	CHE 205F	3	—	2	9
Inorganic Chemistry I	CHE 217F	2	—	—	5
Calculus	MAT 280F	3	—	2	9
Non-technical Elective					8
Term 2S					
Physicochemical Principles in Chemical Engineering II	CHE 202S	2	3	—	8
Industrial Process Operations II	CHE 206S	3	6	2	13
Organic Chemistry	CHE 207S	3	3	—	10
Applied Math in Chemical Engineering	CHE 208S	2	—	1	6
Inorganic Chemistry II	CHE 218S	2	—	—	5
Non-technical Elective					8
Practical Experience	APS 299				

*A voluntary pre-session course offered by the Senior Staff in Chemical Engineering prior to the commencement of regular courses in Second Year.

THIRD YEAR CHEMICAL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thermodynamics and Kinetics I	CHE 301F	3	6	2	14
Applied Mathematics in Chemical Engineering	CHE 305F	2	—	1	6
Organic Chemistry II	CHE 309F	3	9	—	14
Mass Transfer Operations I	CHE 310F	2	—	2	8
Open Elective					8
Term 3S					
Thermodynamics and Kinetics II	CHE 302S	3	6	2	14
Mass Transfer Operations II	CHE 311S	2	4½	1	11
Fluid Mechanics	CHE 314S	3	1½	1	10
Chemical Engineering Topics*	CHE 318S	3	—	—	6
Open Elective**					8

*Fundamental Process Modelling and Simulation
Organic Chemistry of High Polymers
Chemical Engineering Economics

**A student must include a basic science course in his program. In order to satisfy this requirement, a student should substitute a basic science course for one of the technical electives in Fourth Year, as outlined on page 23.

FOURTH YEAR CHEMICAL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thesis, Public Dissertation and Seminar	CHE 499	—	8	2	10
Free Elective					8
two of:*					
Chemical Engineering Thermodynamics	CHE 402F	2	—	1	7
Interface Kinetics	CHE 403F	2	—	1	7
Polymer Engineering	CHE 415F	2	—	1	7
Pulp and Paper Chemistry, Technology and Engineering	CHE 417F	2	—	1	7
Chemical Reactors	CHE 432F	2	—	1	7
Food Chemistry and Engineering	CHE 448F	2	—	1	7

FOURTH YEAR CHEMICAL ENGINEERING (CONTINUED)

two of:*					
Chemical Plant Design	CHE 405F	—	—	6	7
Process Modelling and Simulation	CHE 407F	2	—	3	7
Strategy of Product and Process Development	CHE 408F	2	3	—	7
Advanced Separation Processes	CHE 410F	2	—	1½	7
Atmospheric Dispersion	CHE 446F	2	—	1½	7
Pipeline Transportation	CHE 412F	2	—	1½	7
Introduction to Nuclear Engineering	CHE 427F	2	—	1	7
Term 4S					
Thesis, Public Dissertation and Seminar	CHE 499	—	12	3	17
Free Elective					8
three of:*					
Applied Nuclear Chemistry	CHE 418S	2	—	1	7
Ceramics	CHE 420S	2	—	1	7
Co-ordination Chemistry	CHE 422S	2	—	1	7
Environmental Engineering	CHE 423S	2	—	1	7
Instrumental Methods	CHE 425S	2	—	1	7
Advanced Inorganic Chemistry	CHE 426S	2	—	1	7
Optimal Control	CHE 431S	2	—	1	7
Topics in Applied Chemical Thermodynamics	CHE 404S	2	—	1	7
Interfacial Phenomena and Disperse Systems	CHE 433S	2	—	1	7
Chemistry of Organic Compounds	CHE 434S	2	—	1	7
Plastics Engineering	CHE 444S	2	—	1	7
Petroleum Engineering	CHE 445S	2	—	1	7
Catalysis	CHE 447S	2	—	1	7
Composite Materials	CHE 413S	2	—	1	7
Nuclear Chemical Engineering	CHE 449S	2	—	1	7
Other Technical Elective		—	—	—	7

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*A student must include a basic science course in his program. In order to satisfy this requirement, a student should substitute a basic science course for one of the technical electives in the Fourth Year, as outlined on page 23.

Electrical Engineering

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Special Lecturer:
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ELECTRICAL ENGINEERING

Program 7

Electrical engineers are concerned with all forms of electrical phenomena and applications. The early applications of electricity – the generation, transmission and utilization of electrical energy and the communication of information – are still important, but have been or are likely to be transformed by new applications and potential applications such as magneto-hydrodynamic generation, transmission by superconductors, and satellite communication. In addition, there are completely new fields of application which were not even envisaged a few years ago. There is a growing demand for complex electrical measuring and control equipment for a wide variety of non-electrical processes, and for electronic computers capable of the rapid processing of large volumes of information and the solving of increasingly complex problems.

Within any of these areas the electrical engineer may be engaged in research, development, design, manufacture, operation or management. He may have to assist other engineers and scientists in widely differing fields by supplying them with techniques or insights unfamiliar to them, as for example, in the developing field of bio-medical engineering, or he may have to coordinate the application of many technologies in a single project.

It is obvious then, from the wide range of his possible involvement, that the electrical engineer needs a professional education of great breadth and depth. In the undergraduate course, stress is laid on building a solid foundation of engineering science and design technique. The time limitation requires that only material which is essential can be included; much that might be immediately helpful must be omitted to make room for that which will be relevant for several years. In addition, the undergraduate is given the opportunity of studying non-technical subjects of his own choice.

The electrical engineering makes extensive use of mathematical techniques and concepts; mathematics is thus of the utmost importance and a large portion of the course is devoted to it. Fundamental subjects such as mechanics, electrical physics, chemistry and thermodynamics get considerable attention in the early years. The basic electrical engineering subjects (electromagnetic field theory, electronics, machine principles and circuit theory) follow these, with expansion and specialization in the final year. In the final year, students freely select their whole program from a wide range of elective subjects. The undergraduate course is intended to provide a base on which to build the continuing education that is needed throughout the engineer's career.

Electrical engineering is characterized by the relatively large proportion of its graduates who proceed to post-graduate study to get advanced training in a particular area. Information on this may be obtained from the calendar and other publications of the School of Graduate Studies.

For the First Year curriculum see Division A, page 26.

SECOND YEAR ELECTRICAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations	MAT 290F	3	—	2	8
Complex Variables & Vector Calculus	ELE 200F	3	—	2	8
Circuit Theory I	ELE 210F	3	1½	1	9
Materials Science I	MMS 221F	3	1½	—	8
Dynamics	MEC 205F	2	—	1	7
Non-Technical Elective					8
Term 2S					
Numerical and Probabilistic Methods	ELE 201S	3	—	2	8
Electric and Magnetic Fields	ELE 221S	3	—	2	8
Circuit Theory II	ELE 211S	3	1½	1	9
Materials Science II	MMS 227S	2	1½	—	7
Electronic Circuits A	ELE 231S	2	1½	1	8
Non-Technical Elective					8

THIRD YEAR ELECTRICAL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Electromechanical Systems I	ELE 312F	3	1½	1	9
System and Signal Analysis A	ELE 310F	3	—	2	9
Physical Electronics A	ELE 335F	2	1½	—	6
Fields and Waves	ELE 320F	2	1½	1	8
Thermodynamics and Statistical Mechanics	PHY 384F	3	—	1	8
Open Elective					8
Term 3S					
Digital Systems	ELE 314S	2	1½	—	6
Electromechanical Systems II	ELE 313S	3	1½	1	9
System and Signal Analysis B	ELE 311S	3	1½	1	9
Physical Electronics B	ELE 336S	2	—	1½	6
Electronic Circuits B	ELE 331S	3	3	—	10
Open Elective					8

FOURTH YEAR ELECTRICAL ENGINEERING

	Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
	Free Elective					8

Select additional courses from the following to total 48 units[2] for the term including at least 32 units from Group A.

	Group A					
	Thesis[4]	ELE 498F	—	—	—	8
	Thesis[4]	ELE 496F	—	—	—	16
	Communication Systems A	ELE 416F	2	3	—	8
1	→Switching Theory	ELE 405F	2	—	2	8
	→Electromagnetic Theory	ELE 420F	2	—	2	8
	Control Systems I	ELE 410F	2	1½	1	8
1	→Electromechanical Systems III	ELE 419F	2	1½	1	8
	→Applied Optics	ELE 448F	2	1½	1	8
	Electronic Circuits C	ELE 430F	2	3	—	8
	Computer Programming and Data Structures	ELE 440F	2	—	2	8
1	→Semiconductor Physics	ELE 435F	2	1½	1	8
	→Power System Analysis	ELE 413F	2	1½	1	8
1	→Network Theory	ELE 412F	3	—	2	8
	Group B					
	→Engineering as a Profession[5]	ELE 449F	2	—	2	8
	Other Technical Elective[3]		—	—	—	8

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[1] Courses joined by arrows cannot be taken together because of timetable conflicts.

[2] For students proceeding at a normal rate, see page 171 for minimum and maximum loadings.

[3] Any third or fourth year courses offered by departments of the Faculty of Applied Science and Engineering and listed in the programs of this calendar are acceptable. Where enrolments are limited (as noted in the calendar) the student is responsible for obtaining the necessary approval. Other technical or physical science courses require the approval of the teaching department offering the course and the Department of Electrical Engineering.

[4] A thesis is compulsory. The minimum weighting is 8 for the year. The maximum permitted is 16 for the year. Thus the selections allowed are any one of ELE 496F, 497S, 498F or 499S; or both of ELE 498F and ELE 499S. The selection must be approved by the student's thesis supervisor.

[5] Limited enrolment.

FOURTH YEAR ELECTRICAL ENGINEERING (CONTINUED)

Term 4S

Free Elective 8

Select additional courses from the following to total 48 units[2] including at least 32 units from Group A.

	Group A					
	Thesis[4]	ELE 499S	—	—	—	8
	Thesis[4]	ELE 497S	—	—	—	16
	Control Systems II	ELE 411S	2	1½	1	8
	Computer Organization	ELE 441S	2	3	—	8
1	→Power Semiconductor Circuits	ELE 433S	2	3	—	8
	→Communication Systems II	ELE 454S	2	3	—	8
	→Biomedical Engineering[5]	ELE 445S	3	1½	—	8
1	→Quantum Electronics	ELE 437S	3	1½	—	8
	→Illumination[5]	ELE 447S	3	1½	—	8
1	→Microwave Electronics	ELE 457S	2	1½	1	8
	→Power System Control	ELE 414S	2	1½	1	8
	Integrated Circuits	ELE 431S	2	3	—	8
	→Switching Circuits	ELE 432S	2	3	—	8
	→Microwaves and Optics	ELE 421S	2	1½	1	8
1						
	Group B					
	→Nuclear Reactors and Instruments	CHE 429S	2	1½	1	8
	→Acoustic Theory and Noise Control	AER 414S	2	1½	—	8
	Other Technical Elective[3]		—	—	—	8

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[1] Courses joined by arrows cannot be taken together because of timetable conflicts.

[2] For students proceeding at a normal rate, see page 171 for minimum and maximum loadings.

[3] Any third or fourth year courses offered by departments of the Faculty of Applied Science and Engineering and listed in the programs of this calendar are acceptable. Where enrolments are limited (as noted in the calendar) the student is responsible for obtaining the necessary approval. Other technical or physical science courses require the approval of the teaching department offering the course and the Department of Electrical Engineering.

[4] A thesis is compulsory. The minimum weighting is 8 for the year. The maximum permitted is 16 for the year. Thus the selections allowed are any one of ELE 496F, 497S, 498F or 499S; or both of ELE 498F and ELE 499S. The selection must be approved by the student's thesis supervisor.

[5] Limited enrolment.

Metallurgy and Materials Science

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METALLURGY AND MATERIALS SCIENCE

Program 8

In terms of its diversity and scale of operation, the metallurgical industry in Canada ranks among the world's outstanding industrial achievements; it is also responsible for a considerable portion of the country's economy. Thus, in this field of endeavour, the metallurgist fulfils an important and useful role in the extraction, fabrication and application of metals and their alloys.

In recent years the needs of modern society have made increasingly severe demands upon materials required for various types of construction. This had led to the development of the new field of materials science which applies many of the techniques of the metallurgist and others to the study of the relationship between the structure and properties of a wide spectrum of materials. For example, aerospace travel requires materials capable of withstanding extremes of heat, cold and pressure; the practical application of nuclear energy is limited only by the availability and costs of materials which can withstand in-pile operation; advances in communications depend upon the development of materials having special electrical and magnetic properties.

The program is perhaps unique in the Faculty in that it draws heavily on both physics and chemistry. It should, therefore, appeal to students with an interest in either of these basic scientific fields. The program is designed to place primary emphasis upon the fundamental principles of chemical metallurgy, physical metallurgy and materials science. In the Fourth Year, each student prepares a thesis on an experimental problem which, where possible, is related to research in progress within the Department. A wide range of electives in the Third and Fourth Years culminates in a final Term 4S which consists entirely of material chosen by the student in consultation with an assigned staff tutor. In this manner, the student may elect courses which emphasize either the industrial or the research aspects of metallurgy and materials science.

The Department is equipped with modern facilities for the study of the structure and properties of materials. This equipment includes mass spectrometers, x-ray diffraction units, an electron beam microprobe analyzer, electron microscopes, several optical metallographs, and materials preparation and testing equipment. Facilities for mineral processing and for the production and measurement of high temperatures and high vacuum are also available.

For the First Year curriculum see Division A, page 26.

SECOND YEAR METALLURGY AND MATERIALS SCIENCE

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Calculus	MAT 293F	2	—	2	8
Introduction to Modern Physics	PHY 282F	3	—	1	7
Mechanics of Materials	CIV 204F	3	1½	—	8
Structure of Materials and Metallography	MMS 201F	2	3	1	8
Physical Chemistry I	MMS 202F	2	1	2	8
Non-technical Elective					8

SECOND YEAR METALLURGY AND MATERIALS SCIENCE (CONTINUED)

Term 2S					
Calculus and Differential Equations	MAT 294S	2	—	2	8
Probability and Statistics	STA 282S	2	—	2	8
Physical Chemistry II	MMS 203S	2	—	3	8
Metallurgical Chemistry	MMS 204S	2	3	2	9
Materials Science	MMS 205S	4	—	—	7
Non-technical Elective					8
Practical Experience	APS 299	—	—	—	—

THIRD YEAR METALLURGY AND MATERIALS SCIENCE

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations	APM 391F	2	—	2	8
Mineral Processing I	MMS 301F	2	3	1	8
Thermodynamics	MMS 302F	2	—	4	8
Physical Metallurgy	MMS 303F	3	3	—	8
Open Elective					8
and one Materials Science elective:(1)(2)					
Materials Science Laboratory	MMS 331F	—	3	1	7
Polymer Engineering	CHE 415F	2	—	1	7
Physical Electronics A	ELE 335F	2	1½	—	6
Physical Electronics I	ELE 350F	2	1½	—	7
Introduction to Solid State Physics	PHY 334F	2	—	—	8
Term 3S					
Numerical Methods	CSC 236S	2	—	1	7
Transport Phenomena	MEC 349S	3	1½	1½	8
Physics of Metals	MMS 304S	3	3	—	8
Extractive Metallurgy I	MMS 305S	4	3	—	9
Open Elective					8
and one of:(1)(2)					
Extractive Metallurgy Laboratory	MMS 332S	—	3	1	7
Applied Nuclear Chemistry	CHE 418S	2	—	1	7
Ceramics	CHE 420S	2	—	1	7

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(1)With the approval of the Chairman of the Department, any other suitable technical course may be substituted as an elective.

(2)The student must consult with his assigned staff tutor before choosing technical electives. Departmental electives for which there is insufficient demand may be withdrawn.

FOURTH YEAR METALLURGY AND MATERIALS SCIENCE

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Electrical Systems	ELE 470F	3	3	—	9
Extractive Metallurgy II	MMS 401F	3	3	1	9
Solid State Science	MMS 402F	3	3	1	9
Thesis	MMS 499	—	6	—	6
Free Elective					8
and one of:(1)(2)					
Hydrometallurgy	MMS 413F	2	1½	1	8
Powder Metallurgy	MMS 431F	2	—	1	8
Introduction to Nuclear Engineering	CHE 427F	2	—	1	7
Operational Research I	IND 301F	2	—	2	8
Term 4S					
Thesis	MMS 499	—	12	—	12
Free Elective					8
two of:(2)					
Electrochemical Processes	MMS 404S	2	—	2	7
Advanced Chemical Metallurgy	MMS 406S	1	—	3	7
Metallurgical Systems Analysis	MMS 407S	2	—	1	7
Mineral Processing II	MMS 412S	2	1½	—	7
Operational Research II	IND 302S	2	—	2	8
and two of:(2)					
Materials Engineering	MMS 408S	3	—	—	7
Advanced Materials Science	MMS 411S	3	3	—	8
Nuclear Materials	MMS 416S	3	—	1	7
Composite Materials	CHE 413S	2	—	1	7

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(1) With the approval of the Chairman of the Department, any other suitable technical course may be substituted as an elective.

(2) The student must consult with his assigned staff tutor before choosing technical electives. Departmental electives for which there is insufficient demand may be withdrawn.

Aerospace Studies

TEACHING STAFF OF THE INSTITUTE FOR AEROSPACE STUDIES

Professor and Director of the Institute:

G. N. Patterson, B.SC.(ALTA.), M.A., PH.D., LL.D., D.SC., F.R.S.C., F.R.A.E.S., F.C.A.S.I., F.A.I.A.A., F.A.A.A.S.

Professors and Assistant Directors:

J. H. deLeeuw, DIP. ING.(DELFT), M.S. in A.E.(GEORGIA TECH.), PH.D., F.C.A.S.I. (*Assistant Director – Research*).

I. I. Glass, B.A.SC., M.A.SC., PH.D., F.A.P.S., F.A.A.A.S., F.C.A.S.I. (*Assistant Director – Education*).

Professors:

B. Etkin, B.A.SC., M.A.SC., D.ENG., F.R.S.C., F.C.A.S.I., F.A.I.A.A.
J. B. French, B.A.SC., M.SC.(BIRMINGHAM), PH.D.
G. K. Korbacher, DIP. ING.(BERLIN), PH.D.(BRAUNSCHWEIG)
H. S. Ribner, B.S.(CAL. TECH.), M.S.(WASH.), PH.D.(WASH.), F.A.P.S., F.A.S.A., F.C.A.S.I.

Associate Professors:

P. C. Hughes, B.A.SC., M.A.SC., PH.D.
G. W. Johnston, B.A.SC., M.A.SC., PH.D.
R. M. Measures, B.SC., A.R.C.S., D.I.C., PH.D.(LOND.)
P. A. Sullivan, B.E., M.E.(N.S.W.), D.I.C., PH.D.(LOND.)
R. C. Tennyson, B.A.SC., M.A.SC., PH.D.

Assistant Professors:

J. W. Locke, B.A.SC., M.A.SC., PH.D.
L. D. Reid, B.A.SC., M.A.SC., PH.D.
P. C. Stangeby, B.SC., M.SC., DIPL. PLASMA SCI., D.PHIL.(OXON)

Laboratory Supervisor:

A. A. Haasz, B.A.SC., M.A.SC.

AEROSPACE SCIENCE AND ENGINEERING

The University of Toronto offers a broad and coherent program of studies in the aerospace sciences and engineering. It is designed to prepare its graduates for work in a variety of areas including civil air transportation, design and development of new aircraft, spacecraft and air cushion vehicles, and fundamental research in many of the relevant underlying areas of science. Future Canadian needs for air and surface transportation, satellite communications, and survey satellites are significant factors in determining the content of the courses and the research projects undertaken.

The courses of study available comprise a basic 4 year program leading to the B.A.Sc. degree, an additional year leading to the M.Eng. or M.A.Sc. degree, and a subsequent Doctoral program. The undergraduate (Bachelor's) program consists of four years in Engineering Science (option 5A), and the post-graduate programs are taken in the Department of Aerospace Science and Engineering of the School of Graduate Studies.

(i) *Undergraduate Program.* The details of the undergraduate program are given in this Calendar (page 51) and are seen to consist mainly of intensive studies in the fundamentals of mathematics, physics, and engineering sciences correlated with design and synthesis activities illustrative of modern engineering practice in the aerospace field. In the final two years the program is oriented to the special needs of the aerospace field, and includes some highly specialized courses. The aerospace-related subjects in these two years are taught by the faculty of the Institute for Aerospace Studies. Graduates of this program are able to fill a variety of positions in education, industry and government, but the fifth year (see below) is recommended for those who wish to improve their qualifications for employment as aerospace engineers.

(ii) *Graduate Program.* If the student's academic record in the undergraduate program meets the requirements for admission to the School of Graduate Studies, he may pursue during a fifth year a program as a candidate for the M.A.Sc. or M.Eng. degree in the (graduate) Department of Aerospace Science and Engineering. Details of entrance regulations and courses of study are given in the Calendar of the School of Graduate Studies. The facilities of the Institute for Aerospace Studies are available to the student for research or project work. For details of research fields, assistantships, scholarships and demonstratorships, students should consult the secretary of the graduate department.

It should be noted that a student who has graduated in another branch of engineering, or in science or mathematics, and who desires to qualify as an aerospace engineer may be admitted to the graduate program. In that case the courses leading to the M.A.Sc. or M.Eng. degree will be arranged on an individual basis so that any deficiencies in undergraduate training are made up.

The facilities of the Institute are available for further graduate study and research leading to the Ph.D. degree.

Outline of Courses

On the following pages are brief outlines of the courses prescribed for students in the Faculty of Applied Science and Engineering, listed in alphabetical order of the prefixes (AER, CIV etc.) which identify the teaching department. The suffix following the course number indicates the term in which the course is given; the second line of the description shows the program and year in which the course is prescribed, and the number of hours of lectures, laboratory and tutorial work per week, and the weight units assigned to the course. For example:

MEC 205F	Dynamics				
II–7		2	–	1	7

indicates a fall-term course offered by the Department of Mechanical Engineering for students in Second Year Electrical Engineering. The course consists of 2 hours lectures, no laboratory, and 1 hour tutorial per week, and has a weight of seven units.

Many course descriptions include a statement of prerequisites and corequisites for the information of students, but the absence of such a statement does not imply that the course does not have prerequisites.

The recommendations for textbooks should be considered as tentative only, and subject to change. Students should therefore not purchase textbooks until they have been in attendance in the course, unless informed otherwise by their department.

Interpretation of suffixes to course numbers:*

F: a first-term course.

S: a second-term course.

F/S: indicates that the course given in the Fall Term is repeated in the Spring Term; a student may take one or the other, but not both.

C: the first half of a full year course taken in the Faculty of Arts and Science; Engineering students will be evaluated at the end of the first term.

*The absence of a suffix indicates that the course continues over both terms.

D: the second half of the above. (Both parts of the course must be taken.)

X: when added to a course offered in the Faculty of Arts and Science, signifies that a laboratory course with a different number has been added for Engineering students.

Y: a half-course in the Faculty of Arts and Science given over a full year.

AEROSPACE

AER 301F MECHANICS

III – 5a, 5p 3 – 1½ 8

Mechanics of particles: fixed axes, rotating and moving axes, orbital dynamics, rockets. Mechanics of rigid bodies: fixed axes, body-attached axes, gyroscopes. Mechanics of linear systems: free and forced oscillations, coupled systems, waves on a string. Rayleigh's method. Lagrange's equations, Hamiltonians. Calculus of variations. Special topics by request. Primary Reference: class notes. Reference books: *Principles of Dynamics* – Greenwood. *Introduction to Theoretical Physics* – Page. *Principles of Mechanics* – Synge and Griffith.

H. S. Ribner

AER 302F MECHANICS OF STRUCTURES

III – 5a 3 – 1½ 8

Basic theorems and principles in the theory of structures (strain energy, virtual displacements, minimum total potential energy). General theory of bending of beams (unsymmetrical bending, thin walled structures, shear flow in multiflanged beams, open and closed sections). General theory of torsion (thin walled structures, multicell structures, shear centre). Theory of elastic instability (buckling of slender elastic struts, flat and curved plates, shells). Plane stress problems (Airy and Prandtl stress functions). Application of theory to the design of aerospace structures is given in tutorials.

R. C. Tennyson

AER 303F AEROSPACE LABORATORY I

III – 5a – 3 – 8

Prepared experiments and/or laboratory projects in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility analysis and design construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report required.

A. A. Haasz

AER 304S AEROSPACE LABORATORY II

III – 5a **– 3 – 7**

For course outline see AER 303F (Aerospace Laboratory I).

A. A. Haasz

AER 305S FLUID MECHANICS

III – 5a **3 – 1½ 8**

Introductory concepts and idealizations of real fluids; theory of incompressible inviscid flow including potential flow, vorticity, complex potential, conformal transformations; viscous fluid flow, turbulence; Navier-Stokes equations; introduction to boundary layer theory. Reference books: *Fundamentals of Hydro and Aeromechanics* – Prandtl and Tietjens; *Fluid Dynamics* – Streeter; *Hydrodynamics* – Lamb.

P. C. Stangeby

AER 401F AERODYNAMICS

IV – 5a 3 – 1½ 9

Thin airfoil theory, vortex theory, finite wings, compressibility effects, supersonic and hypersonic wing theory. Propulsion: Momentum theorem, propeller actuator disc analysis, blade element approach, axial compressors and turbines. Air cushion vehicles. Aircraft performance; drag, basic performance parameters, range, turning flight, take-off. Illustrative design methodology. Basic concepts in static stability and control. Reference Books: *Foundations of Aerodynamics* – Kuethe and Schetzer; *Aerodynamics of V/STOL Flight* – McCormick.

J. B. French

AER 402F SPACE FLIGHT DYNAMICS

IV – 5a 2 – 1½ 8

Kepler's problem; time of flight; Lambert's problem; trajectory design; coordinate systems and orbital elements; orbit determination; impulse thrust approximation; patched conic approximation; manoeuvres; three-body problem; lunar trajectories; rigid body in torque-free motion; gravity-gradient potential; librations of rigid body in circular orbit; spinning rigid body in circular orbit; dissipation effects; effects of structural flexibility.

P. C. Hughes

AER 403F ADVANCED MECHANICS OF STRUCTURES

IV – 5a 2 – 1½ 8

Matrix analysis of redundant structures including the force and displacement methods. Flexibility and stiffness matrices for structural elements derived, effects of thermal strains and structural cutouts. Automated techniques for determining redundant members. The finite element approach, derived, and applied to plates and shells. The method of individual displacements, with solutions given for buckling loads, natural frequencies and stress distributions in structures. Application of analytical methods to the design of aerospace structures is given in tutorials. Reference Books: *Theory of Matrix Structural Analysis* – J. S. Przemienicki, McGraw-Hill, New York (1968). *The Finite Element Method in Structural and Continuum Mechanics* – Zienkiewicz, O. C. and Cheung, Y. K., McGraw-Hill, London (1967).

R. C. Tennyson

AER 404F PHYSICS AND MECHANICS OF SOLIDS

IV – 5a 3 – 1½ 9

Properties of solids, the factors on which they depend. Structural imperfections, atom movements, dislocation theory. Deformation and failure of metals. Metal fatigue, service loads and service load laboratory simulation, statistical evaluation of fatigue data. Microstructural changes in metal due to fatigue, fatigue damage accumulation, crack initiation and propagation. Some useful approximations for fatigue design. Reference Books: *Materials Science for Engineers* – Van Vlack. *Dislocation and Fracture in Elastic Continua* – W. R. Lardner. *Fatigue: A Complex Subject (Some Simple Approximations)* – S. S. Manson.

G. K. Korbacher

AER 406F ENGINEERING DESIGN I

IV – 5a – 3 – 8

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Emphasis is placed on projects permitting students to independently carry out the preliminary and innovative stages of design. Recent design projects include spacecraft design, vehicle simulator design, and air cushion vehicle design. Drawings and reports are prepared as required.

G. W. Johnston

AER 407S ENGINEERING DESIGN II

IV – 5a – 3 – 7

For course outline see AER 406F.

G. W. Johnston

AER 408F AEROSPACE LABORATORY III

IV – 5a – 6 – 8

Prepared experiments and/or laboratory projects in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required.

A. A. Haasz

AER 409S AEROSPACE LABORATORY IV

IV – 5a — – 6 – 7

For course outline see AER 408F (Aerospace Laboratory III).

A. A. Haasz

AER 410S GASDYNAMICS

IV – 5a — 3 – 1½ 9

Fundamental phenomena occurring in compressible flows are treated. Basic thermodynamics and the equations of inviscid and viscous compressible flows are reviewed. Compressible flows in nozzles, diffusers, and ducts with viscous and diabetic effects, and shock and expansion waves in both steady and nonstationary flows including high temperature effects that cause departures from the perfect gas law and equilibrium, are discussed. The lectures are illustrated by about 20 synthesizing analytic and engineering examples in a tutorial laboratory. Reference Books: *Elements of Gasdynamics* – Lipemann and Roshko. *Dynamics and Thermodynamics of Compressible Fluid Flow* – Shapiro. (Prerequisite AER 305S)

S. J. Townsend

AER 411S STABILITY AND CONTROL OF AIRCRAFT

IV – 5a — 3 – 1½ 9

Introduction to the dynamic stability and control-response of aircraft. Equations of motion for small perturbations from steady flight; longitudinal stability; lateral stability; response to throttle, elevator, aileron, rudder; flight in turbulence. Reference Book: *Dynamics of Flight-Stability and Control* – Etkin. (Prerequisite AER 401F)

L. D. Reid

AER 412S AEROELASTICITY

IV – 5a — 2 – 1½ 8

Static aeroelastic phenomena are studied, including divergence of slender wings, the effect of low aspect ratio, sweep and wing-aileron interaction. Various methods of solution are considered such as closed form, matrix format iteration and the Rayleigh-Ritz approach. A study of vibration and flutter of wings and control surfaces is presented with particular emphasis on those parameters which affect flutter speed. Reference Books: *An Introduction to The Theory of Aeroelasticity*, Fung, Y. C., Dover Paperback Publications (1969).

R. C. Tennyson

AER 414S ACOUSTIC THEORY AND NOISE CONTROL

IV – 5a, 7 (elective) — 2 1½ – 8

Basic acoustic theory including acoustic plane waves in infinite medium, real fluid effects, radiation of sound in three dimensions, sound propagation in ducts, and architectural acoustics. Noise control theory including transmission and radiation of sound by solid structures, mufflers, filters, resonators, enclosures and porous lining, sound propagation outdoors, subjective response to noise and industrial sources.

H. S. Ribner, G. W. Johnston

AER 415F FUNDAMENTALS OF LASERS, PLASMAS AND ENERGY

IV – 5a, 5e 3 – 1½ 9

Energy – world situation, energy conversion schemes: solar, fusion, fission, MHD; review of atomic physics and Maxwell's equations, fundamentals of spectroscopy, introduction of plasma physics, plasma spectroscopy, lasers and their properties, gas-dynamic lasers, laser diagnostics of plasmas, thermonuclear fusion plasmas.

R .M. Measures

APPLIED MATHEMATICS

APM 391F DIFFERENTIAL EQUATIONS

III – 8, III – 4 (elective) 2 – 28

First and second order ordinary differential equations, operational methods, variation of parameters, solution in series. Bessel and Legendre functions, the Laplace transform. (Prerequisite MAT 294S)

F. V. Atkinson

APM 393F DIFFERENTIAL EQUATIONS I

III – 5 3 – – 8

Ordinary differential equations, matrix linear systems, qualitative properties of solutions, stability, asymptotic behaviour, nonlinear systems, calculus of variations, Sturm-Liouville problems, separation of variables.

APM 441F DIFFERENTIAL EQUATIONS II

IV – 5 3 – – 8

Partial differential equations of second order, generalized functions, Fourier transforms, wave, diffusion and harmonic equations, Green's functions, eigenvalues and eigenfunctions, variational properties, cylindrical and spherical functions with applications.

W. D. Lakin

APM 446S APPLIED FUNCTIONAL ANALYSIS

IV – 5 3 – – 8

Hilbert and Banach spaces, with applications, dual spaces, linear operators, elements of spectral theory, extremal problems, integral and functional equations, nonlinear operators, stochastic differential equations.

W. D. Lakin

APPLIED SCIENCE AND ENGINEERING — INTERDEPARTMENTAL

APS 100F & S COMPUTER PROGRAMMING

I – 1, 2, 3, 4, 6, 7, 8 1 – 3 7

The digital computing system as a device for numeric and non numeric transformation of numbers and symbols. Constants, variables, and arrays; arithmetic and logical expressions; functions. Algorithms, represented by flow chart and computer languages. Conditional branching and looping; iteration; sub-programs; input/output. All of the above will be illustrated and implemented using the FORTRAN IV language. Applications will include root finding, numerical integration, sorting, iterative design and graph plotting.

APS 101S ENGINEERING DESIGN

I – 1, 2, 3, 4, 5, 6, 7, 8 (elective) 2 1 1½ 8

Lectures will deal with the sequence of design steps by which engineers find acceptable solutions for stated technological needs. These include need definition, ideation, problem modelling, feasibility and economic analysis, the decision process, specification and presentation. A series of seminars will be used to study "case" problems and to consider such topics as the engineer's responsibility to society. Laboratory time will be devoted to small group design projects.

APS 201S ENGINEERING DESIGN

II – 5 (elective) – – 6 8

This course provides instruction and experience in the application of engineering design techniques that lead from a stated technological need to an acceptable solution. Students will work singly or in small groups on design projects and will have lecture/discussion sessions on problem identification, ideation, design criteria, feasibility analysis and decision making. Special topics related to the projects, such as materials, economics, reliability, etc., will be covered as required. At least one of the projects will be carried through to the drawing and specification stage and, if possible, constructed. Class size is limited to twenty students. Reference Books: *An Introduction to Engineering & Engineering Design*, second edition, E. V. Krick, John Wiley and Sons. *Introduction to Engineering Design*, T. T. Woodson, McGraw-Hill.

APS 299 PRACTICAL EXPERIENCE

Students in the programs listed below are required to have, before graduation, practical work of a nature acceptable to the department concerned. This may be obtained during the summer vacations but work done before entering the Faculty may also meet the requirements. Instructions will be issued by the departments concerning the type of work which is acceptable. Practical experience certificate forms may be obtained from the departments and should be returned there when completed.

Program 1	600 hours	Program 6	600 hours
Program 2	600 hours	Program 8	600 hours

APS 300F ENGINEERING LAW

II 3 1 – – 2

A course designed to co-ordinate the practice of engineering and law. Consideration is given to the characteristics, advantages and disadvantages of companies, partnerships, the promotion, organization and financing of companies, the duties of employees to employers, the duties and liabilities of engineers, statutes applicable to engineering works, professional engineering associations, construction contracts, workmen's compensation, trade unions and industrial disputes. Reference Book: *Engineering Law* – Laidlaw, Young, and Dick.

E. S. Langdon, W. O. C. Miller

APS 401 PROJECT DESIGN

IV – 1, 3, 4, 5, 6, 7, 8 (elective) – – 5 8

This elective, limited to about twenty participants, provides an unusual opportunity for small interdisciplinary student design groups to seek and test solutions for engineering problems with social relevance. Considerable freedom is given in self-structuring of the groups and selection of the problems. Emphasis is placed on management of the design activity and on group effectiveness. Similar topics and instruction are selected to support the particular needs of the groups. Building and testing of prototypes, when applicable, is encouraged; written and oral presentation, with discussion of results, is required.

Permission to substitute this course for other electives and/or for thesis must be obtained from the student's department before being accepted into it. Further details may be obtained from Professor I. W. Smith or Professor M. Townsend.

APS 495, 496, 497, 498S, 499 THESIS IV-5

Every student in fourth year Engineering Science is required to prepare a thesis on an approved subject. Instructions concerning the thesis requirements are issued during the spring term of third year, and copies may be obtained in the division office. The weight allocated in each term of each option is shown in the fourth year curriculum.

The thesis will be graded after submission in the spring term, and the grade included in the weighted average for that term only. The weight assigned will be the sum of the weights for both terms.

CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

CHE 100F CHEMISTRY

I – 1, 2, 3, 4, 6, 7, 8 3 3 1 12

An introductory course in physical chemistry involving problems dealing with industrial and engineering applications. Topics discussed are stoichiometry and the mole concept, ideal and real gas behaviour, phase equilibria and colligative properties of solutions, chemical and ionic equilibrium, electrochemistry, thermochemistry and chemical kinetics.

The lecture course is supplemented by a series of laboratory experiments illustrating the principles discussed. Experiments include a gas-chromatographic study of fuel combustion, caustic-chlorine and sulphuric acid pilot plants, freezing point depression, molecular weight determination, vapour pressure, steam and binary distillations, qualitative analysis, heat of neutralization, kinetics, corrosion, pH and electrochemistry.

S. Sandler and Staff in Chemical Engineering

CHE 101S CHEMICAL ENGINEERING PROJECTS

I – 1, 2, 3, 4, 5, 6, 7, 8 (elective) — — — 8

A course concerning several topics of wide interest to engineers, in which each student may choose *three* Chemical Engineering Projects during the term. Each five week project is given by a specialist in his field of interest and includes laboratory sessions during which the student may design and execute a particular investigation related to the lecture course. Some of the projects include:

Separation Processes (Mackay)
Nuclear Kinetics (Hewitt)
Environmental Chemistry (Phillips, C. R.)
Fiber Engineering (Rozeiu)
Combustion (Sandler)
Polymer Engineering (Williams)
Photochromic Tracers (Hummel)
Ceramic Engineering (Barham)
Electrochemical Energy Sources (Graydon)
Mineral Processing (Hewer)
Plastics Engineering (Woodhams)
Chemical Complexes (Smith, Burgess)
Rheology (Chaffey)
Catalysis (Phillips, M. J.)
Composite Behaviour (Piggott)
Biomedical Engineering (Wang)

A topic will be given in any year in which more than 20 students elect to take it.

R. T. Woodhams and Staff in Chemical Engineering

CHE 102F CHEMISTRY

I – 5 3 3 1 10

CHE 100F with alternative assignments.

W. H. Burgess and Staff in Chemical Engineering

CHE 201F PHYSICOCHEMICAL PRINCIPLES IN CHEMICAL ENGINEERING I

II – 6 2 – – 5

The following topics are discussed: PVT behaviour of fluids and fluid mixtures (equations of state, principle of corresponding states, compressibility factors, etc.), reaction stoichiometry, energy conversion and thermochemistry, phase equilibrium and phase diagrams.

R. W. Missen

CHE 202S PHYSICOCHEMICAL PRINCIPLES IN CHEMICAL ENGINEERING II

II – 6 2 3 – 8

This course provides an introduction to chemical thermodynamics and chemical kinetics. The second law of thermodynamics is discussed and applied to solutions, phase equilibrium, reaction equilibrium, including cell reactions and surfaces; in kinetics attention is focussed on ideal reactor models, rate laws, reaction mechanisms and catalysis. Laboratory work involves experiments for both 201F and 202S.

R. W. Missen

CHE 203F ANALYTICAL CHEMISTRY LABORATORY

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A voluntary course beginning August 22 is offered by the Senior Staff in the Department of Chemical Engineering and Applied Chemistry. The course is designed to provide experience in precise analytical measurements. Problems relevant to industry and the ecological environment will be examined. Application should be made to the Chairman of the Department by April 30.

J. W. Smith and Senior Staff in Chemical Engineering

CHE 204F ANALYTICAL CHEMISTRY

II – 6 2 10½ – 14

The course consists of experimental work and lectures on qualitative and quantitative chemical analysis, illustrating the principles of equilibrium and coordination chemistry and of important instrumental methods, in particular electroanalytical and opticometric methods. The growing role of analytical chemistry in environmental engineering and in the setting of environmental standards will be discussed by way of examples. Experimental work can include an independent project designed to advance the knowledge in a selected field. Textbooks: *Quantitative Chemical Analysis* – Fischer and Peters. Strongly recommended, *Fundamentals of Analytical Chemistry*, Skoog and West.

J. W. Smith and C. R. Phillips

CHE 205F INDUSTRIAL PROCESS OPERATIONS I

II – 6 3 – 2 9

The theory of momentum and heat transfer and the fundamentals of momentum, heat and mass balances of chemical engineering practice are discussed. A tutorial problem class accompanies this course. Textbooks: *Principles of Unit Operations* – Faust et al. *Basic Principles and Calculations in Chemical Engineering* – Himmelblau.

I. H. Spinner, W. G. MacElhinney

CHE 206S INDUSTRIAL PROCESS OPERATIONS II

II – 6 3 6 2 13

The fundamentals of transfer processes are discussed with particular reference to heat transfer operations in chemical engineering. A laboratory illustrating the principles and practice of transfer operations is also given. A tutorial problem class accompanies the lecture material. Textbooks: *Principles of Unit Operations* – Faust et al. *Unit Operations of Chemical Engineering* – McCabe & Smith.

W. G. MacElhinney, J. W. Smith, I. H. Spinner

CHE 207S ORGANIC CHEMISTRY

II – 6 3 3 – 10

An introductory lecture and laboratory course in organic chemistry, with emphasis on structure. Textbook: *Modern Organic Chemistry* – Griffin.

W. H. Rapson

CHE 208S APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

II – 6 2 – 1 6

Application of differential equations to problems of chemical engineering interest. Emphasis is on the formulation of differential equations together with their solution by analytical and numerical methods. Reference Book: *Applied Differential Equations* – M. R. Spiegel.

R. Luus

CHE 209F CHEMICAL SYSTEMS

II – 5 3 3 – 8½

The themes discussed are conservation, equilibrium and rate of change in chemical systems. These are applied to topics in various engineering fields. Laboratory work illustrating the principles with emphasis on individual projects accompanies the lectures.

C. E. Chaffey

CHE 214F INORGANIC CHEMISTRY I

II – 2A 2 – – 7

CHE 217F with alternative assignments.

R. E. Jervis

CHE 215S INORGANIC CHEMISTRY II

II – 2A 2 – – 8

CHE 218S with alternative assignments.

R. L. Hummel

CHE 217F INORGANIC CHEMISTRY I

II – 6 2 – – 5

Periodicity in physical and chemical properties of the elements are studied in relation to atomic structure. Descriptive chemistry of representative and some transition elements are correlated with structure. Textbook: *University Chemistry* – Mahan (second ed.).

R. E. Jervis

CHE 218S INORGANIC CHEMISTRY II

II – 6 2 – – 5

Useful quantum models are developed for atoms and for atomic and molecular orbital bonding mechanisms. Concepts discussed include: electronegativity, Z-effective, ionic compounds, covalent bond lengths and energies, partial ionic character of bonds, coordination and complexation.

R. L. Hummel

CHE 301F THERMODYNAMICS AND KINETICS I

III – 6 3 6 2 14

The power sources which have supported our civilization are ultimately based on the exploitation of chemical potentials. This course is an examination of the ultimate energy transformation and the rates at which they may be provided, together constituting a complete description of the Gibbsian power sources.

Laws of conservation and the concept of entropy together wtih theories of chemical reaction rates and mechanisms of selected chemical processes will be discussed in an historical context. These concepts will be illustrated by chemical engineering problems encountered in the design and operation of the means of production.

W. F. Graydon, W. H. Burgess

CHE 302S THERMODYNAMICS AND KINETICS II

III – 6 3 6 2 14

A re-statement of the material described in course CHE 301F with additional quantitative applications taken from Chemical Engineering practice.

W. F. Graydon, W. H. Burgess

CHE 303F THERMODYNAMICS AND KINETICS I

III – 5c 2 3 – 9

Course 301F with reduced laboratory or tutorial assignments.

W. F. Graydon

CHE 304S THERMODYNAMICS AND KINETICS II

III – 5c 2 3 – 9

Course 302S with reduced laboratory or tutorial assignments.

W. F. Graydon

CHE 305F APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

III – 6 2 – 1 6

Analysis and solution of chemical engineering problems which require knowledge of the rational design of experiments, treatment of experimental data and tests of hypotheses. The application of probability to selected topics of chemical engineering interest. Reference Books: *Probability and Statistics for Engineers* – I. Miller and J. E. Freund. *Engineering Statistics* – Bowker and Lieberman.

I. H. Spinner

CHE 309F ORGANIC CHEMISTRY II

III – 6 3 9 – 14

A continuation of course 207S. Textbook: *Modern Organic Chemistry* – Griffin.

J. G. Breckenridge

CHE 310F MASS TRANSFER OPERATIONS I

III – 6 2 – 2 8

The study of the fundamentals of mass transfer. Theory and practice of applications to gas-liquid mass transfer processes, including gas absorption, stripping, drying and humidification. Textbook: *Mass Transfer Operations*, 2nd ed. – R. E. Treybal.

D. Mackay, O. Trass, R. F. Hunter, D. Basmadjian

CHE 311S MASS TRANSFER OPERATIONS II

III – 6 2 4½ 1 11

The study of distillation, including extractive and azeotropic distillation, solvent extraction, adsorption, membrane separation and other separation processes. Illustrative laboratory experiments. Textbook: *Mass Transfer Operations*, 2nd ed. – R. E. Treybal.

D. Mackay, O. Trass, R. F. Hunter, D. Basmadjian

CHE 312F MASS TRANSFER OPERATIONS I

III – 5c, III – 2B (elective) 2 – 2 9

Course 310F but with alternative assignments.

D. Mackay, O. Trass, R. F. Hunter, D. Basmadjian

CHE 313S MASS TRANSFER OPERATIONS II

III – 5c; 2B (elective) 2 – 1½ 8

Course 311S with no laboratory assignments, and alternative tutorial assignments.

D. Mackay, O. Trass, R. F. Hunter

CHE 314S FLUID MECHANICS

III – 6 3 1½ 1 10

Laminar and turbulent flow of Newtonian and non-Newtonian fluids, fluid-particle systems, two-phase flow, pumps; important application of fluid mechanics in the process industries and the environment.

M. E. Charles

CHE 315F CHEMICAL ENGINEERING PROBLEMS AND LABORATORY I

III – 5c – 2 – 7

Laboratory experiments and problems illustrating selected topics discussed in subject CHE 301F.

W. F. Graydon

CHE 316S CHEMICAL ENGINEERING PROBLEMS AND LABORATORY II

III – 5c –2–7

Laboratory experiments and problems illustrating selected topics discussed in subjects CHE 302S and CHE 317S.

W. F. Graydon

CHE 317S POLYMER CHEMISTRY

III – 5c 3––8

An introductory course in the chemical structures and syntheses of polymeric materials including resins, plastics, elastomers and fibers. Emphasis will be placed on the more important commercial polymeric materials and their chemical modification by cross-linking, grafting and vulcanization.

R. T. Woodhams

CHE 318S CHEMICAL ENGINEERING TOPICS

III – 6 3––6

The following topics are covered:

Fundamental Process Modelling and Simulation –

Modelling of elementary chemical engineering processes leading to differential equations and arising from the application of the principles of thermodynamics, kinetics, fluid mechanics, and heat and mass transfer to chemical engineering problems.

D. Basmadjian, M. E. Charles, I. H. Spinner

Organic Chemistry of High Polymers –

Organic high polymers can be prepared by various mechanisms which are extensions of the organic chemical reactions studied earlier. Free radical, cationic, anionic and coordination complex catalysts produce different polymers with appropriate monomers. The nature of these reactions are discussed.

W. H. Rapson, I. H. Spinner

Chemical Engineering Economics –

A systems approach to planning chemical enterprises. The objectives, profitability and benefit-cost analyses are discussed, as are criteria for engineering decision making and typical Canadian and overseas engineering projects. Textbooks: *Plant Design and Economics for Chemical Engineers* – Peters and Timmerhaus. *Systems Analysis for Engineers and Managers* – de Neufville and Stafford.

M. Wayman

CHE 402F CHEMICAL ENGINEERING THERMODYNAMICS

IV – 6 (elective) 2–17

Thermodynamic properties of real gases and of ideal and non-ideal liquid solutions. Chemical reaction equilibria. Selected problems.

W. H. Burgess

CHE 403F INTERFACE KINETICS

IV – 6 (elective) 2 – 1 7

A course on the chemical kinetics of catalytic processes.

W. F. Graydon

CHE 404S TOPICS IN APPLIED CHEMICAL THERMODYNAMICS

IV – 6, IV – 5c (elective) 2 – 1 7

Chemical process applications of thermodynamics including compression and expansion of fluids, refrigeration and cryogenics, phase equilibrium in separation processes and reaction equilibrium in reactor processes; description of real systems in thermodynamic terms, including use of fugacity and excess functions, is developed concurrently.

R. W. Missen

CHE 405F CHEMICAL PLANT DESIGN

IV – 6 (elective) – – 6 7

This is a course based on synthesis and creativity. Teams of about 6 students each design and cost a chemical plant. The plants are chosen based on current Canadian needs and interests.

M. Wayman

CHE 406F CHEMICAL PLANT DESIGN

IV – 5c (elective) – – 6 9

CHE 405F with alternative assignments.

M. Wayman

CHE 407F PROCESS MODELLING AND SIMULATION

IV – 6 (elective) 2 – 3 7

Extensive practice in the setting up and solving of mathematical models of a large variety of processes connected with the chemical, metallurgical and other industries, as well as environmental and biomedical phenomena. Models involve the application of chemical engineering fundamentals (fluid flow, heat and mass transfer, chemical thermodynamics and kinetics) to the simulation of steady and unsteady state processes. Solution by analytical, analog and numerical methods. Reference text: *Process Modelling Manual* – D. Basmadjian.

D. Basmadjian, M. E. Charles, I. H. Spinner

CHE 408F STRATEGY OF PRODUCT AND PROCESS DEVELOPMENT

IV – 6 (elective) 2 3 – 7

The strategical approaches needed for the solution of engineering problems involving the creation of novel unit operation equipment and novel processes, both for chemical and non-chemical products.

R. F. Hunter, I. H. Spinner

CHE 409F STRATEGY OF PRODUCT AND PROCESS DEVELOPMENT

IV – 5c (elective) 2 3 – 9

CHE 408F with alternative assignments.

R. F. Hunter, I. H. Spinner

CHE 410F ADVANCED SEPARATION PROCESSES

IV – 6 (elective) 2 – 1½ 7

Theory and application of a number of separation processes, including multicomponent distillation (using computational techniques), azeotropic and extractive distillation, liquid extraction, transient behaviour and cyclic processes, and solid-liquid contacting operations. Illustrative design problems.

D. Mackay, O. Traas

CHE 412F PIPELINE TRANSPORTATION

IV – 6 (elective) 2 – 1½ 7

A course based on the theory and practice of moving gases, liquids and solids by pipelines both within chemical plants and over long distances. Operating pipeline systems are used as examples, and the course includes a feasibility and design study.

M. E. Charles

CHE 413S COMPOSITE MATERIALS

IV – 6, 8; III – 5m (elective) 2 – 1 7

A course on the fundamentals of composite material design, fabrication and evaluation. Topics will emphasize recent developments in the reinforcement of plastics and metals using fibers, flakes, and other particulate fillers. Examples will include the use of such composites in automotive, marine, aircraft, building construction and allied engineering applications.

M. R. Piggott

CHE 415F POLYMER ENGINEERING

IV – 6; III – 5m, 8 (elective) 2 – 1 7

The solid state properties of polymers are discussed, particularly amorphous state and crystallinity. The rheological and viscoleastic properties are then outlined and the effect on these of degradation and failure mechanisms included. A large segment of the course applies to fabrication techniques, their principles, and the products produced. The over-all emphasis is on the relationship of the properties to the structure, and how these affect the uses.

H. L. Williams

CHE 417F PULP AND PAPER CHEMISTRY, TECHNOLOGY AND ENGINEERING

IV – 6 2 – 1 7

The chemistry of wood in relation to pulping, bleaching and papermaking processes, the equipment involved and the economics of converting wood into paper.

W. H. Rapson

CHE 418S APPLIED NUCLEAR CHEMISTRY

IV – 6; III – 5m, nt, 8 (elective) 2 – 1 7

An introduction to the principles and methods of radioisotope chemistry. Applications of nuclear techniques and radioactive materials in chemical technology and in nuclear power generating systems. Topics to be covered include: radioisotope methods of studying chemical reaction mechanisms and kinetics, chemical process development and process control, nuclear reactions applied to chemical analysis (activation analysis), radiation chemical processing.

R. E. Jervis

CHE 420S CERAMICS

IV – 6, 8, III – 5m, 8 (elective) 2 – 1 7

An introduction to the field of ceramics, including a description of the available raw materials, the production of refractories and glasses, and high-temperature experimental techniques.

D. Barham

CHE 422S CO-ORDINATION CHEMISTRY

IV – 6 (elective) 2 – 1 7

The fundamental principles underlying co-ordination compounds: bonding, geometry and isomers, stability, etc., leading to an understanding of examples such as chlorophyll and sequestering agents.

J. G. Breckenridge

CHE 423S EVIRONMENTAL ENGINEERING

IV – 6 (elective) 2 – 1 7

Strategy (management, law, economics) and technology for environmental control of chemical processes. Dispersion and effects of effluents in the environment. Environmental impact studies. Specifically the following are discussed: environmental standards and their bases, measurement parameters and methods, sampling and monitoring, atmospheric reactions and behaviour of wastes in water bodies, meteorological principles and dispersion, water treatment principles (primary, biological, physical and chemical) and air pollution control principles (particles and gases).

C. R. Phillips

CHE 425S INSTRUMENTAL METHODS

IV – 6 (elective) 2 – 1 7

The subject is designed to emphasize the science of chemical instrumentation. The principles, techniques, and applications of gas-chromatographic, opticometric, electrometric and mass-spectometric methods of analysis are studied.

S. Sandler

CHE 426S ADVANCED INORGANIC CHEMISTRY

IV – 6 (elective) 2 – 1 7

Periodicity and trends in physical and chemical properties of the compounds of the principal elements are discussed. These are correlated, predicted and classified both in terms of classical concepts and equations of quantum mechanics.

R. L. Hummel

CHE 427F INTRODUCTION TO NUCLEAR ENGINEERING

IV – 6, IV – 8 (elective) 2 – 1 7

Nuclear engineering aspects of: nuclear constitutions and properties including cross-sections, energetics, radioactivity; production and use of radio-isotopes; neutrons, slowing-down, diffusion of thermal neutrons; fission, the fission reactor; heat transfer; radiation measurement and control; materials for reactor fuel, can, moderator and coolant and their behaviour in the nuclear environment.

D. G. Andrews

CHE 429S NUCLEAR REACTORS AND INSTRUMENTS

IV – 7 (elective), IV – 5e (elective) 2 1½ 1 8

The purpose of this course is to provide electrical engineering students with an orientation in the nuclear energy field and to develop in terms of the basic physical processes involved and understanding of (1) the kinetic behaviour of nuclear reactor systems and (2) the principles of operation of nuclear instruments for application in industry, medicine and nuclear research. The six laboratory periods associated with this course provide intensive involvement with actual nuclear facilities including the SLOWPOKE critical reactor, the uranium-heavy water neutron multiplying assembly, and modern radiation spectrometers. In addition, special laboratories stress the fundamental aspects of nuclear radiation measurement and reactor analog simulation.

J. S. Hewitt

CHE 431S OPTIMAL CONTROL

IV – 6 (elective) 2 – 1 7

Fundamentals of optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: *Optimal Control of Engineering Process* – Lapidus and Luus.

R. Luus

CHE 432F CHEMICAL REACTORS

IV – 2B, IV – 6 (elective) 2 – 1 7

An introduction to the rational design and analysis of chemical reactors. Topics are:

chemical kinetics and development of the rate law, including homogeneous and heterogeneous systems and catalysis; reactor models (batch, tubular, stirred-tank), including isothermal, non-isothermal and adiabatic operation. Reference Books: *Chemical Reactor Theory* – K. G. Denbigh, *Chemical Reaction Engineering* – O. Levenspiel.

R. W. Missen

CHE 433S INTERFACIAL PHENOMENA AND DISPERSE SYSTEMS

IV – 6 (elective) 2 – 1 7

A course in surface chemistry, interfacial phenomena and disperse systems (aerosols, emulsions, colloids, surface films, etc.) with chemical engineering applications. The textbook, *Interfacial Phenomena* – J. F. Davies, and E. K. Rideal, is taken as a guide, but additional material is covered especially on aerosols, colloids and adsorptive bubble separation methods.

C. R. Phillips

CHE 434S CHEMISTRY OF ORGANIC COMPOUNDS

IV – 6 (elective) 2 – 1 7

A course based on the structures, reactions and properties of carbohydrates, proteins, lipids, dyes and steroids including the toxicology of some industrial organic compounds.

P. Y. Wang

CHE 435F RATE PROCESSES I

IV – 5c 3 – – 9

Introduction to momentum, heat and mass transfer. Transport properties from kinetic theory of gases. Fluid flow concepts, integral mass, force and energy balances, Bernoulli's equation, friction. Equations of motion and boundary layer equations. Turbulent transport. Compressible flow.

O. Trass

CHE 436S RATE PROCESSES II

IV – 5c 3 – – 9

Total energy and thermal energy equations. Heat Transfer: Fourier's laws, heat transfer coefficients and equations. Component mass balances, mass transfer coefficients and Fick's laws. Momentum, heat and mass transfer analogies. Applications of the above fundamentals.

O. Trass

CHE 437F OPTIMAL CONTROL OF CHEMICAL SYSTEMS

IV – 5c (elective) 3 – 1½ 9

Fundamentals to optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: *Optimal Control of Engineering Processes* – Lapidus and Luus.

R. Luus

CHE 439S SELECTED TOPICS IN ORGANIC CHEMISTRY

IV – 5c (elective) 3 – – 9

A short course in the preparation, structure, and reactions of carbohydrates, proteins, heterocyclic compounds, chemotherapeutic agents, steroid hormones, alkaloids, and synthetic organic polymers.

P. Y. Wang

CHE 440S MODELLING AND SIMULATION OF CHEMICAL SYSTEMS

IV – 5c (elective) 3 – – 9

Applications of elements of chemical and physical rate processes to chemical engineering problems. Chemical reactor stability, complex chemical system dynamics and process control. Application of analog, digital simulation, and hybrid computers to the solutions of problems in the above topics.

I. H. Spinner

CHE 441F CHEMICAL ENGINEERING PROJECT

IV – 5c (elective) – 6 – 9

An experimentally oriented research project.

Senior Staff in Chemical Engineering

CHE 442F NUCLEAR REACTOR FUNDAMENTALS

IV – 5nt 3 3 – 11

This course, using appropriate mathematic tools, explains in terms of fundamental physical processes the design considerations and operational behaviour of existing, projected, and conceptual nuclear reactor systems for the generation of useful energy or radiation products. The physical processes of importance are nuclear fission, nuclear fusion, neutron diffusion, the interaction of various types of radiation with nuclei and condensed matter, and the heating and containment of plasmas. Topics include the conditions for criticality, the kinetic behaviour and the control of fission chain reactors, as well as the projected criteria whereby controlled fusion will become a reality. Environmental aspects and the international implications of nuclear energy will be discussed. The laboratory periods provide a first-hand opportunity to study the kinetic response of the SLOWPOKE critical reactor and to perform reactor physics measurements on the uranium heavy-water neutron multiplying assembly. The use of radiation sources and modern nuclear instruments in a variety of applications is investigated. Electrical analogs are used to supplement kinetic studies of reactor systems. (Prerequisite PHY 335F or equivalent.) Text: *Nuclear Reactor Theory*, Lamarsh, Addison-Wesley.

D. G. Andrews, J. S. Hewitt

CHE 443 ORGANIC CHEMISTRY

Elective 2 3 – 8, 2 3 – 8

A comprehensive, elementary, organic chemistry course available to students in any year other than those enrolled in Program 6, intending to qualify for entrance into the Faculty of Medicine. Lectures and laboratories are scheduled at times convenient to those registered. The lectures cover the simple hydrocarbons, their halogen and oxygenated derivatives, amino derivatives, and other derivatives of importance to biological systems, all with emphasis on structure and functionality. The major part of the course is spent on amino acids, sugars, and fatty esters with emphasis on natural and synthetic polymers of biological interest or use. The concurrent laboratory emphasizes typical laboratory reactions of these classes of materials.

H. L. Williams

CHE 444S PLASTICS ENGINEERING

IV – 6 (elective) 2 – 1 7

An intensive study of the chemical and physical properties of plastics materials and their use in product design. The principles of reinforcement with respect to fillers, fibers, flakes and microballoons will be presented including the practical aspects of materials selection, processing, fabrication and evaluation. The tutorial periods will be devoted to actual case histories involving recent developments. Reference Book: *The Modern Plastics Encyclopedia.*

R. T. Woodhams

CHE 445S PETROLEUM ENGINEERING

IV – 6 (elective) 2 – 1 7

A course utilizing the principles of Chemical Engineering and presenting the fundamentals of engineering design and processing as they apply to refinery operations that produce petroleum products and important chemicals from petroleum.

W. G. MacElhinney

CHE 446F ATMOSPHERIC DISPERSION

IV – 6 (elective) 2 – 1½ 7

Problems of assessing the dispersive role of the atmosphere as a means of controlling air pollution are considered, as well as related topics such as source sampling and effects of air quality on the feasibility of industrial plants and residential areas. Textbook: *Meteorology and Atomic Energy*, 1968.

J. W. Smith

CHE 447S CATALYSIS

IV – 6 (elective) 2 – 1 7

An introduction to heterogeneous and homogeneous catalysis including adsorption, kinetics of catalytic reactions, the nature of the catalyst surface and a consideration of some specific catalytic reactions.

M. J. Phillips

CHE 448F FOOD CHEMISTRY AND ENGINEERING

IV – 6 (elective) 2 – 1 7

Principles involved in the industrial handling of biological materials for food purposes. Engineering operations in the manufacture of food products. Invited lectures will cover specialized industrial topics.

L. J. Rubin

CHE 449S NUCLEAR CHEMICAL ENGINEERING

IV – 6 (elective) 2 – 1 7

Fuel cycles; large-scale production of transuranium elements; growth and decay of fission product activities; chemical processing of irradiated fuels – extraction, absorption, complexing, chemical separation; transport and storage of radioactive wastes; environmental problems; isotope separation by physical means – diffusion, centrifuges, cascades.

D. G. Andrews, R. E. Jervis

CHE 452S NEUTRON AND PHOTON TRANSPORT

IV – 5nt 3 – 2 10

This is a course on radiative transport theory and its specific application to problems in nuclear energy such as reactor and accelerator shielding, the optimal design of reactor lattice configurations, the prediction of reactor fuel burnup, and the implications of these for reactor control and fuel cycle management. The Boltzmann transport equation is derived in general form and its historical significance indicated. Analytical and numerical solutions are investigated and realistic scattering kernels for neutrons and photons are developed. The current state of computer code development for reactor calculations is reviewed. (Prerequisite PHY 335F and APM 441F or equivalents.) Text: *Linear Transport Theory*, Case and Zweifel, Addison-Wesley, 1967.

D. G. Andrews, J. S. Hewitt

CHE 499 THESIS, PUBLIC DISSERTATION AND SEMINAR

IV – 6 – 8 2 10 – 12 3 17

The thesis will be graded after submission in the spring term and the grade included in the weighted average for that term only. The weight assignment will be the sum of the weights for both terms.

Senior Staff in Chemical Engineering

CIVIL ENGINEERING

CIV 100F APPLIED MECHANICS

I – 1, 2, 3, 4, 6, 7, 8 3 – 2 10

Statics: The principles of statics are applied to the composition and resolution of forces, moments and couples. The equilibrium states of frames are examined. Dynamics: Applications of the principles of dynamics are discussed for motion on straight and curved paths. Work, energy and momentum concepts are applied to particles, systems of particles and rigid bodies. Throughout statics and dynamics the free body concept is emphasized and vector algebra is used where it is most useful.

G. T. Will and Staff in Civil & Mechanical Engineering

CIV 101F MECHANICS (STATICS)

I – 5 2 – 1 6

Translational and rotational resultants and equilibrants are discussed together with equivalent force systems in two- and three-dimensional space. Emphasis is placed on systems in equilibrium. Distributed forces, applications to structures, friction, method of virtual work, potential energy and stability of equilibrium are considered.

S. M. Uzumeri, M. P. Collins

CIV 135F & S ENGINEERING GRAPHICS

I – 1, 2, 3, 4, 6, 7, 8 2 5 – 8

A course to provide an introduction to graphical communication in contemporary engineering practice. Topics in descriptive geometry and engineering drawing include orthographic projection, single view drawings, spatial analysis, developments and intersections, sketching, preparation of graphs and nomographs and the reproduction of drawings.

C. A. Wrenshall and Staff in Civil Engineering

CIV 136S ENGINEERING GRAPHICS

I – 5 (elective) 2 – 2½ 8

A course on the use of graphical theories and methods as a means of visual communication in the development of engineering concepts. The lectures and laboratory problems deal with the ideas, problem refinement, solution analysis and solution implementation.

R. D. Foster

CIV 203S MECHANICS OF MATERIALS

II – 5 (elective) 2 – 3 8

Structural design philosophy and methods; structural properties of engineering materials: basic relationships between force and deformation of bars; behaviour of structural components subjected to axial load, bending, shear, and torsion; stress and strain transformations; instability; design of simple structures.

M. P. Collins

CIV 204F MECHANICS OF MATERIALS

II – 8 3 1½ – 8

The fundamental relations among stress, strain and applied load are worked out for tension, compression, twisting and bending in the elastic and inelastic ranges, for various egineering materials. The buckling of struts and columns is examined. Laboratory: An experimental study of engineering materials and structural members under various loading conditions. (Prerequisite CIV 100F).

A. C. Davidson

CIV 205S MECHANICS OF MATERIALS

II – 4 (elective) 2 3 – 8

An introduction to the elastic behaviour of solids under various load conditions. The basic concepts of strength and stiffness are examined and their application to the design of elementary structural systems considered. Laboratory: An experimental study of engineering materials and structural members under load. (Prerequisite CIV 100F)

J. D. Barber

CIV 209S ENGINEERING MATERIALS

II – 1, 2C 4 2 1 10

Deals with the basic principles necessary for the undertaking and selection of materials used in Civil Engineering and points out the significance of these in practice. Fundamentals which provide a common basis for the properties of various materials are stressed.

One third of the laboratory time is devoted to demonstrations illustrating the fundamentals covered in the lectures, the remaining time to project work in small groups (Prerequisite CIV 210F)

J. Timusk, G. B. Craig

CIV 210F STRENGTH OF MATERIALS

II – 1, 2C; 2A, 2B (elective) 3 – 1 8

An introduction to the elastic and inelastic behaviour of solids under various load conditions. Stress, strain, and deformation relations are determined for members subjected to tension, compression, torsion and bending forces. (Prerequisite CIV 100F)

J. D. Barber

CIV 211S MECHANICS AND DESIGN OF STRUCTURES

II – 1 4 – 2 10

This course is primarily an introduction to structural design and topics examined include basic concepts, types of structures, loads, safety factors, specifications and common failure modes. The design of structural components in steel, concrete and timber using the National Building Code is investigated.

Topics to be covered in engineering mechanics include virtual work, energy methods in structural analysis and an introduction to vibration. (Prerequisite CIV 210F)

S. M. Uzumeri

CIV 240S ENVIRONMENTAL SYSTEMS

II – 1, 2C 2 – – 5

Growth and distribution of population; the trend to urbia; cycles of life, energy and materials in nature; biological hazards of pollution. Air pollution: damages, economy, control possibilities. Water pollution: purification and distribution of water, collection and treatment of waste water. Soil pollution: refuse disposal, home disposal of sewage.

A. P. Bernhart

CIV 255F SURVEYING

II – 1; II – 2, IV – 2C (elective) 3 2 1 9

General principles and practice of surveying including: measurement of horizontal distances, horizontal angles, vertical distances. Survey calculations, sources of errors, corrections and adjustments. Route surveying, construction surveying and introduction to airphoto interpretation and photogrammetry.

B. J. Haynes and Staff in Civil Engineering

CIV 260F COMPUTER PROGRAMMING

II – 1 2 – 2 8

This course continues the study of programming requirements and techniques introduced in course APS 100F/S; the full standard FORTRAN language is used; emphasis is placed on subprogram philosophy and organization, and on flow charts and program documentation. Engineering problem oriented languages such as ICES-COGO and ICES-STRUDL are introduced and used. Some experience is provided in the use of a time-shared interactive computing system and in computer graphics. (Prerequisite APS 100F/S)

R. A. Collins

CIV 267F THE ENGINEER AND HIS ENVIRONMENT

II – 2C; 2A, 2B (elective) 2 2 2 8

An introduction to the role of the engineer in the solution of society's problems. Lectures, seminars and discussion periods by staff of all areas of Civil Engineering and guest speakers. Projects on qualitative solutions to engineering problems. Instruction and practice in presentation of technical data and reports.

Staff in Civil Engineering

CIV 268S THE CIVIL ENGINEER AND HIS PROFESSION

II – 1 2 2 2 8

An introduction to the different facets of Civil Engineering. Lectures, seminars and discussion periods by staff of all areas of Civil Engineering and guest speakers. Group projects on qualitative solutions to comprehensive engineering problems.

Staff in Civil Engineering

CIV 312F DESIGN OF STRUCTURES II

III – 1 3 – 2 9

A course on the design of structures with emphasis on the design and analysis of determinate systems. Detailing and fabrication aspects of such structures in steel and in reinforced concrete are examined. (Prerequisite CIV 211S)

J. D. Barber

CIV 313S DESIGN OF STRUCTURES III

III – 1 3 – 2 10

A course on the design of structures with emphasis on indeterminate systems. Topics considered include the analysis of indeterminate structures by moment distribution and by approximate methods, design of reinforced concrete footings, retaining walls and continuous slabs, introduction to prestressed concrete. (Prerequisite CIV 312F)

R. H. Mills

CIV 321F SOIL MECHANICS

III – 1, 2C; III – 2A, 2B; IV – 2 (elective) 2 1 – 6

Identification and classification of soils for engineering purposes; properties, permeability and drainage characteristics, effective stresses, consolidation and settlement, shearing strength, compaction, stabilization, frost action. Laboratory sessions include identification of soil samples and determination of mechanical properties of soil.

E. I. Robinsky

CIV 322S FOUNDATIONS

III – 1, 2C; 2A (elective) 2 1 1 7

Site investigations and sampling, response of soil to load, lateral earth pressure, retaining walls, braced cuts, anchored bulkheads, bearing capacity, shallow foundations, settlement, deep foundations, slope stability. Laboratory sessions are devoted to design problems. (Prerequisite CIV 211S, CIV 321F)

F. A. DeLory

CIV 327S PLEISTOCENE GEOLOGY

III – 2C; 2A (elective) 3 – 2 8

The causes, extent, and effects of Pleistocene ice caps, especially in North America. Origin and classification of land-forms of glacial origin. Methods of dating and analyzing these deposits. Periglacial phenomena, including permafrost. The extent of and the economic and engineering significance of glacial deposits in North America.

CIV 328F MINING TECHNOLOGY I

III – 2B; 2A, 2C (elective) 3 – 1 8

An introduction to mining practice, and its basic unit operations and processes; including drilling and blasting, acquisition of mineral lands. Sampling theory and practice provide background for future evaluation problems.

H. R. Rice

CIV 329S MINING TECHNOLOGY II

III – 2B; 2A, 2C (elective) 3 – 1 8

Mine layouts and principal mining methods as applied to geological situations and stress environments. Further study of cost-making factors, including transportation, mine hoisting. Introduction to mine-smelter relationships, and other economic aspects. (Prerequisite CIV 328F)

H. R. Rice

CIV 330S TRANSPORTATION SYSTEMS

II – 1, IV – 2C (elective) 3 – 2 8

A brief history of Canadian transportation development and a discussion of current policy, regulation and administration structure introduces a comparative study of transportation modes including their cost characteristics. The principles of location, flows on networks and the concepts of capacity and control are studied. The transportation planning process is introduced with emphasis on analytical techniques.

R. M. Soberman

CIV 340S MUNICIPAL ENGINEERING

III – 1 2 – 2 7

Quantities of water and waste water; hydrologic cycle, analysis of hydrologic data, applications of hydrology to engineering design; waste water collection systems, water distribution systems, refuse disposal, administration and financing of municipal works. Laboratory: Design problems supplementing lecture material. (Prerequisite MEC 351F, corequisite CIV 240S)

J. G. Henry

CIV 358F SURVEY CAMP

III – 1; III – 2A, 2C (optional) – – – 8

At Survey Camp, students obtain further experience in the use of instruments and in the essentials of survey practice. Emphasis is placed on adjustments of levels and transits, route surveys, higher order surveys, topographic surveys, practical astronomy and photo interpretation. Students entering Third Year Civil Engineering will be required to take the Survey Camp from August 20 to September 4, 1973.

The camp is held at Dorset and Gull Lake with students in attendance paying for the cost of their accommodation.

Applications to defer attendance or for exemption from the camp must be made to the secretary of the Faculty before July 15, 1973. (Prerequisite CIV 255F)

B. J. Haynes and Staff in Civil Engineering

CIV 370F ENGINEERING MATHEMATICS

III – 1 3 – 28

Numerical integration, solution of ordinary and simple partial differential equations by numerical procedures, solution of linear algebraic equations, mathematical programming. (Prerequisite MAT 280F)

G. T. Will

CIV 371F PROBABILITY AND STATISTICS

III – 1 2 – 27

Topics to be considered include definition of probability, binomial, poisson and normal distributions, frequency and sampling distribution. Examples of estimation, hypothesis testing, introduction to experimental design and regression theory.

CIV 375S ENGINEERING ECONOMICS AND DECISION MAKING

III – 1, IV – 1 (elective) 3 – 28

Design as selection between alternatives. Economic efficiency and other goals. The objective function and the use of optimization techniques. Time scale of consequences and its reduction. Interest rate and social rate of return. Market and non-Market valuation. Economic life, replacement and salvage value. Treatment of risk and uncertainty. Public investment. Financing.

E. Hauer

CIV 405F ADVANCED STRENGTH OF MATERIALS

IV – 1 (elective) 3 – 28

Selected topics from the following list are introduced or extended beyond their elementary treatment: elastic buckling of axially loaded bar; torsion of bars having noncircular cross sections; unsymmetrical bending of beams; beams on elastic foundations; curved beams; beam-columns; cables; rings; elementary theory of elasticity; elementary plate theory.

R. A. Collins

CIV 413F MODULAR CONSTRUCTION

IV – 1 (elective) 3 – 28

Systems building approach, types of modular construction. Fundamentals of building science. Materials for modular construction Analysis and design of various modular systems, including panelized construction, formless masonry construction, and prefabricated box units. Joining and erection techniques. Recent developments.

V. R. Riley

CIV 414S ADVANCED ENGINEERING MATERIALS

III – 1, IV – 1 (elective) 3 – 28

In recent years, materials have been subjected to increasingly higher stress levels and corrosive environments. In order to meet these demands, designers have turned to newer materials and structures such as insulating concretes, sandwich panels, polymer modified concretes, and fibre reinforced composites. This course introduces some of the newer materials and techniques which are available, and also deals with conventional problems such as brittle fracture of steel structures.

V. R. Riley

CIV 416F REINFORCED CONCRETE I

IV – 1 (elective) 3 – 2 8

This course covers the behaviour and ultimate strength of reinforced concrete structures. Members subjected to flexure, axial load, shear and torsion are treated. Detailing of reinforcement, the design of floor systems and the design of shear walls are covered. Emphasis is given to the relationship between recent research results and current building codes. (Prerequisite CIV 313S)

M. P. Collins

CIV 417S REINFORCED CONCRETE II

IV – 1 (elective) 3 – 2 8

Prestressed Concrete – tension members, simple span and continuous span flexural members, columns and torsion resisting members. Slender reinforced columns. Yield line methods for slab analysis and design. (Prerequisite CIV 416F)

M. W. Huggins

CIV 418S BEHAVIOUR AND DESIGN OF STEEL STRUCTURES

IV – 1 (elective) 3 – 2 8

The behaviour of structural elements and structures and their connection by welding and bolting are examined and related to design methods and criteria. Topics to be considered include repeated loading, brittle fracture, elastic-inelastic behaviour, buckling and ultimate capacity. (Prerequisite CIV 313S)

CIV 419F INDETERMINATE STRUCTURES

IV – 1 (elective) 3 – 2 8

Internal forces, support reactions, structural displacements and influence lines are computed for continuous beams, arches, closed rings, frames, trusses, Vierendeel trusses and grids. Slope-deflection, moment distribution, Kani, flexibility and stiffness methods, virtual work and Muller-Breslau principles, and Maxwell's law of reciprocal displacements are studied. An introduction to structural analysis by matrix organization is examined. (Prerequisite CIV 313S)

CIV 420S CONSTRUCTION ENGINEERING

IV – 1 (elective) 3 – 2 8

This course deals with business and management aspects of construction – construction company organization, construction tenders and contracts, the elements of a construction project, project management, planning and scheduling, job administration, field engineering; and construction methods and equipment. A number of construction sites and construction material manufacturing plants are visited during the scheduled laboratory periods.

K. A. Selby and Staff in Civil Engineering

CIV 421F FOUNDATIONS AND EARTHWORK

IV – 1 (elective) 3 – 2 8

Design and construction of: foundations for buildings, bridges and other structures including excavation, footings, piling, caissons; retaining walls, sheet pile bulkheads; fills, embankments, earth-fill and rock-fill dams including seepage, dewatering and grouting. The laboratory sessions include design problems and studies of case histories. (Prerequisite CIV 322S)

E. I. Robinsky

CIV 422S ENGINEERING GEOLOGY

III – 1, IV – 1 (elective) 3 – 2 8

The study of engineering practice from a geological point of view. The behaviour of rocks and soils in building and engineering construction, foundations, tunnels, dams, and flood-control works with reference to the importance of the mineral composition of earth and rock materials, their geomorphic and geologic features and their stress history. Engineering case studies will include examination of groundwater, frost and landslide conditions, shoreline engineering, construction in permafrost, earthquake problems, and field investigations. (Prerequisite GLG 280S/GLG 180S)

F. A. DeLory

CIV 423S ENGINEERING GEOLOGY SEMINARS

IV – 2C 3 – 2 8

Applications of geology to evaluation of natural problems (erosion, situation, landslides), regional problems (groundwater, permafrost) and construction problems (dams, tunnels, canals, construction materials). Course is based on study of case histories. Term paper is required.

CIV 424F ROCK MECHANICS

IV – 2C (elective) 3 – 2 8

Physical properties of rock, fundamentals of rock behaviour, and theories of rock failure. Consideration of in situ stresses. Analysis of stress and strain. Elementary principles of design of open excavations and underground excavations. Consideration of testing, excavation support, and instrumentation.

CIV 425F SUBSURFACE EXPLORATION

IV – 2C 3 – 2 8

Planning and executing subsurface explorations in soils and rock to obtain information for the design, construction control and operation of civil engineering and mining projects, and for carrying out remedial actions in the case of distressed structures or distressed areas. Indirect methods (mapping, shallow seismic, pumping, penetration), direct methods (boring, shafts, adits), in situ tests and field instrumentation will be considered. Case histories will be studied.

CIV 426F MINE OPERATION AND ADMINISTRATION

IV – 2 (elective) 2 – 3 8

Operational, financial, legal, and economic considerations in the valuation and management of mineral enterprise. Laboratory work is given on a progressive problem in the estimation of grade and tonnage in an ore situation. While CIV 328F is not a prerequisite, a knowledge of its content would be useful.

H. R. Rice

CIV 427S MINE OPERATION AND ADMINISTRATION II

IV – 2 (elective) 2 – 3 8

A continuation of the subject matter of CIV 426F. In the laboratory the problem evaluated in CIV 426F is pursued through the selection of optimum mining rate and the design of enterprise, complete to the point of financing. (Prerequisite CIV 426F)

H. R. Rice

CIV 429F AIR PHOTO INTERPRETATION

III – 2A, IV – 1, 2 (elective) 3 2 – 8

The principles of interpretation of aerial photographs; processes of formation and erosion of landforms, both unconsolidated and consolidated, with particular emphasis on glaciation, their patterns as seen on aerial photographs, their identification and evaluation, and the engineering problems involved; location of granular materials; soil mapping; investigations from airphotos for highway, powerline, and pipeline locations, damsites and flood control structures; delineation of drainage areas and drainage structure location; classification of muskeg areas and prediction of depth, land use classification. One day field trip, including field soil testing.

CIV 430F TRAFFIC ENGINEERING

IV – 1 (elective) 3 – 2 8

Introduction to the basic principles and methods of Traffic Engineering. Driver, vehicle and roadway characteristics. Description and measurement of traffic streams. Micro and macroscopic properties. Highway intersection capacity. Traffic accidents, their relation to design and their control. Traffic signing and signalization. Area traffic control and surveillance. Illumination. Parking. (Prerequisite CIV 330S)

E. Hauer

CIV 431F TRANSPORTATION PLANNING

IV – 1 (elective) 3 – 28

This course deals with the transportation planning process, with emphasis on urban and regional applications. Surveys and data collection, mathematical models and transportation demand analysis, transit and highway system alternatives, methods of project and systems evaluation.

R. G. Rice

CIV 432S HIGHWAY ENGINEERING

IV – 1, 2 (elective) 3 – 28

A basic course in which the following topics are examined: highway systems and geometric design; highway materials and their behaviour; and pavement systems. The laboratory part of the course is mainly devoted to a design project.

M. M. Davis

CIV 439S URBAN AND REGIONAL PLANNING

III – 1, IV – 1 (elective) 3 – 28

Spatial distribution of land use related to physical, ecological and transportation factors. Economic alternatives for the selection of industrial, residential and recreational location. Land use planning concerning natural resources, resource potential and conservation. Legal aspects of planning. Mathematical modelling and optimization of land use. (Offered jointly by the Department of Urban and Regional Planning and Civil Engineering.)

A. Waterhouse

CIV 440F WATER POLLUTION CONTROL ENGINEERING

IV – 1, 2 (elective) 3 – 28

The basic problems of water and soil pollution and the engineering solutions currently available. The self purification of streams and the physical, chemical and biological treatment processes employed in the design of water and wastewater treatment facilities. Laboratory demonstrations and field trips complement the lectures and class assignments.

J. G. Henry

CIV 441S AIR POLLUTION CONTROL ENGINEERING

IV – 1 (elective) 3 – 28

The pollutants: their sources, quantities and qualities, effects on humans, environment. Distribution and concentrations in city air under various atmospheric conditions, pollution indices. Control processes: change of fuel, dust control by cyclones and electrostatic precipitators; control of gases by adsorbers and scrubbers; exhaust controls for vehicles. Impacts on economy, planning, policy decisions.

A. P. Bernhart

CIV 449S GEOHYDROLOGY

IV – 2 (elective) 2 – 3 8

Ground water as an element of the hydrologic cycle; its relation to the geology of a basin and to water resources management. Mechanics of groundwater flow; methods of investigation and exploitation.

CIV 450F WATER RESOURCES AND HYDROLOGY

IV – 1, 2C (elective) 3 – 2 8

The availability and management of water for optimal use in the broadest sense. Qualitative and quantitative evaluation of surface and ground water sources. Rainfall, runoff and stream-flow analysis. Storage, flood control, diversion and related hydraulic structures. Uses of water and forecasting the demand. Quality standards, ecological, economic, sociological, legal and political factors affecting water management. Benefit/cost analysis. (Prerequisite CIV 340S)

CIV 455F PHOTOGRAMMETRY AND REMOTE SENSING

IV – 1, 2 (elective) 3 2 – 8

Camera as a measuring instrument. Photogrammetric properties of pictures, construction, viewing and measuring of stereoscopic models. Applications in engineering, and mapping. Physical aspects of remote sensing. Spectral characteristics of natural objects. Photographic and nonphotographic remote sensors and their applications in terrain studies, vegetation analysis and natural resource management. Analysis of Earth Resource Satellite data.

J. Vlcek

CIV 456S ENGINEERING APPLICATIONS OF SURVEYING

III – 1, IV – 1 (elective) 3 – 2 8

Theory, methods and instrumentation of engineering surveys. Special applications in civil engineering structures such as: bridges, dams, tunnels, highways, airports, power lines, and pipelines. Introduction to hydrographic surveying. Engineering applications of and introduction to legal surveying as related to engineering projects. (Prerequisite CIV 358F)

B. J. Haynes

CIV 457S CONTROL SURVEYS

IV – 1 (elective) 3 – 2 8

Design and statistical analysis of survey control for engineering cadastral and cartographic work. Detection of structural deformations and earth movement by precise methods. National and municipal control systems and their use in engineering projects. This course is complementary to course CIV 456S (Prerequisite CIV 358F)

R. C. Gunn

CIV 474S PUBLIC SPEAKING

IV – 1 – – 2 3

A subject emphasizing student participation and designed to develop facility in oral presentation before groups. Beginning with short talks, students move on to longer prepared talks on technical subjects. Experience and observation are also offered in the conduct of meetings.

F. A. DeLory & Staff in Civil Engineering

CIV 475F ADMINISTRATION AND MANAGEMENT

IV – 1 2 – – 6

An introduction to the various management functions involved in operating a business; including planning, organizing, staffing, directing, controlling and labour relations. Individual proprietorships, partnerships and limited company operations are discussed.

K. A. Selby, H. L. Macklin

CIV 479F & S SPECIAL STUDIES IN CIVIL ENGINEERING

IV – 1 (elective) 3 – 2 8

Students having the Departmental Chairman's approval, may undertake special studies of advanced topics that are not normally part of the undergraduate program.

CIV 496S THESIS

IV – 2C – 6 – 8

All students in the Fourth Year of the Engineering Geology option must prepare a thesis on an approved subject. Topics are normally submitted for approval in the fall term with the work being done in the spring term under the supervision of a faculty member.

CIV 498F THESIS

IV – 1 (elective) – 4 – 8

With the approval of the Departmental Chairman, a Fourth Year student in Civil Engineering may undertake a 20-unit thesis instead of the usual 12-unit thesis (CIV 499S). Normally such theses will be experimental in nature and the topic must be submitted prior to the commencement of the fall term.

CIV 499F/S THESIS

IV – 1 – 6 – 12

All students in the Fourth Year of the Civil Engineering program must prepare a thesis on an approved subject. Topics are normally submitted for approval in the fall term with the work being done in the spring term under the supervision of a faculty member. (Only those students who will complete the requirements for their degree in a fall term will be permitted to take CIV 499F.)

COMMERCE
(Department of Political Economy)

COM 390F ACCOUNTING I

III – 4 2 – 1 8

Accounting methods and principles; build-up of financial statements.

M. S. Shapiro

COM 391S ACCOUNTING II

III – 4 (elective) 2 – 1 8

Analysis and interpretation of financial statements; introduction to cost accounting and managerial accounting. (Prerequisite COM 390F)

M. S. Shapiro

DEPARTMENT OF COMPUTER SCIENCE

CSC 180F INTRODUCTION TO COMPUTER PROGRAMMING

I – 5 2 2 – 6

A practical introduction to algorithms and PL/I programming; numerical and non-numerical applications.

CSC 236S NUMERICAL METHODS

III – 2B, 8 2 – 1 7

Solution of non-linear equations, approximations, quadrature, solution of systems of linear equations, eigenvalues and eigenvectors, differential equations. Exercises requiring the use of a computer will be assigned. (Prerequisites: APS 100F/S, MAT 180F, MAT 181S. Exclusions: CSC 381F, 386F, 281F, 481S)

N. A. Derzko

CSC 280S COMPUTER LANGUAGES

II – 5 2 – 1 8

Definition of various programming languages including procedure-oriented, list processing, and simulation languages. Specification of syntax and semantics. Basic properties of programming languages. Introduction to formal languages and data structures. (Prerequisite CSC 180F)

P. H. Roosen-Runge

CSC 281F NUMERICAL METHODS

II – 5 2 – 1 7

Non-linear equations, matrices and systems of linear equations, interpolation and approximation, quadrature, solution of ordinary differential equations. Reference: Conte, de Boor, *Elementary Numerical Analysis*, McGraw-Hill, 1972. (Prerequisites: CSC 180F, MAT 185F, 194F, 195S. Exclusions: CSC 236S, 381F, 386S, 481S)

R. A. Mathon

CSC 364S INTRODUCTION TO THE THEORY OF COMPUTATION

III – 5cs 2 – 1 7

Introduction to formal logic – propositional and predicate calculus. Primitive recursive functions, computable functions, recursive functions, and recursive sets. Turing machines, unsolvable problems. Models, flowcharts, and program schemata; application to equivalence, termination, and correctness of programs. Reference: A. Yasuhara "Recursive Function Theory and Logic," Academic Press. (Exclusion: CSC 390S as given before 1973–74. Corequisite: MAT 390S)

J. Mylopoulos

CSC 380S SYSTEM SOFTWARE I

III – 5cs 2 6 – 10

Assembly language programming, job control language, and an introduction to the facilities made available by operating systems. Data structures, including linear and linked lists, stacks, queues, and trees. The principles of language processing. Parsing by precedence and LR(k) techniques. (Prerequisites: CSC 280S and ELE 353F)

CSC 381F NUMERICAL METHODS I

III – 4 2 – 2 8

Roots of equations, interpolation, approximation theory, quadrature, numerical solution of ordinary differential equations. (Prerequisites: IND 202F, MAT 293F, MAT 294S. Exclusion: CSC 236S, 281F, 481S)

CSC 386S NUMERICAL METHODS II

III – 4 (elective) 2 – 2 8

Matrix calculations, eigenvalues, roundoff errors, random numbers, extrema of functions of several variables. (Prerequisite: CSC 381F. Exclusion: CSC 236S, 281F, 481S)

CSC 446S COMPUTATIONAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS

IV – 5cs 2 – 1 8

Initial value problems for partial differential equations. Consistency, convergence, stability. Boundary value problems. Mixed initial-boundary value problems. Difference schemes for nonlinear problems. (Prerequisite: CSC 281F. Recommended: APM 441F)

CSC 468F OPERATING SYSTEMS

IV – 5cs 2 – 1 8

Computational structures. Processes and their cooperation; operating systems functions and facilities. Processor allocation; memory management; input-output and files; resource sharing. Correctness and reliability; protection and security. Design methodology; implementation; measurement and evaluation. (Prerequisite CSC 380S)

CSC 480F SYSTEM SOFTWARE II

IV – 5cs 2 6 – 10

Development of complete software systems, with emphasis on language processors. The organization of compilers, interpreters, assemblers, and loaders; tools which facilitate their construction. The goal of precision programming, and its attainment through structured programming techniques. The laboratory associated with this course will include team projects producing pieces of system software. (Prerequisite: CSC 380S)

J. J. Horning

CSC 481S NUMERICAL METHODS

III – 3, IV – 3 (elective) 3 – 1½ 10

Interpolation and approximation, numerical differentiation and intergration, matfices and systems of linear equations, non-linear equations, numerical solution or ordinary and partial differential equations, statistical methods. Text: "Applied Numerical Methods" by Carnahan, Luther and Wilkes, Wiley, 1969. (Prerequisites: APS 100F/S, MAT 180F, MAT 181S. Exclusions: CSC 236S, 281F, 381F, 386S)

ELECTRICAL ENGINEERING

ELE 121S ELECTRICITY AND MAGNETISM

I – 1, 2, 3, 4, 6, 7, 8 3 1 1 10

A basic course in electricity and magnetism including electric forces and fields, analysis of direct-current circuits, magnetic forces and fields, electromagnetic induction, and an introduction to the conductive, magnetic and dielectric properties of materials. Text: Sears & Zemansky, *University Physics, Part II.*

ELE 150S ELECTRICITY AND MAGNETISM

I – 5 3 – – 8

An introduction to electricity and magnetism adapted to the needs of Program 5. Elements of vector calculus. Coulomb's Law. Gauss Law. Electric field of discrete and continuous charge distributions. Potential functions. Gradient and divergence. Laplace's equation. Method of images. Forces and energy. Capacitance. Forces on moving charges and conductors. Ampere's Law. Biot-Savart Law. Magnetic field of rings and coils. Faraday's Law and applications. Self- and mutual-inductance. Energy stored in a magnetic field. Alternating current circuits; series and parallel. Electric and magnetic fields in matter.

ELE 200F COMPLEX VARIABLES AND VECTOR CALCULUS

II – 7 3 – 2 8

Functions of several variables. Partial differentiation. Differentiation of implicit functions. Maxima, minima. Applications to curve fitting of nonlinear problems. Differentiation of vector functions. Gradient, divergence and Gauss' Theorem. Curl of a vector field and Stokes' Theorem. The operator Del. Applications to Electromagnetic Felds, Maxwell's equations. Theory of Complex Variables, Cauchy-Riemann Equations. Complex integrals. Cauchy's integral theorem and formula. Taylor and Laurent series. Residues. Conformal Mapping and their applications to two-dimensional potential problems. Applications of Complex Integrals to stability of systems. Text: Kreyszig, *Advanced Engineering Mathematics*, 3rd ed., Wiley. (Prerequisite: MAT 181S. Corequisite MAT 290F)

ELE 201S NUMERICAL AND PROBABILISTIC METHODS

II – 7 3 – 2 8

Errors in computation; significance of results in view of physical models. Iterative techniques for solving non-linear equations. Zeros of polynomials; transfer functions of electrical systems. Characteristic value problems; natural frequencies of physical systems. Interpolation; curve fitting; processing of experimental data. Numerical integration. Ordinary differential equations; systems of differential equations as models of electrical and other physical systems. Simulation; validity of models. Elementary probability concepts in engineering. Conditional probability; probability of causes. Random varables and functions; electrical noise. Mean and variance of random variables. Discrete distributions: binomial, Poisson, as they are in physical systems. Continuous distributions: uniform, exponential, normal. Life testing; expected performance; selectivity. Central limit theorem; physical supply networks. Sampling and statistics. Estimation of parameters. Hypothesis testing. All topics are illustrated with examples from engineering practice, accompanied by corresponding computational design exercises. (Prerequisite: MAT 290F)

ELE 210F CIRCUIT THEORY I

II – 7 3 1½ 1 9

Circuits as models for physical devices; relationships between circuit and field concepts. Elementary network theorems and laws. Transient response of circuits. Topology and loop and nodal analysis. Duality. Response to complex frequency excitation. General solution of linear differential equations with constant coefficients. Steady-state response with direct and sinusoidal sources including analysis of polyphase circuits. The laboratory provides an introduction to techniques of electrical measurement. Text: Close *The Analysis of Linear Circuits*. (Prerequisite ELE 121S. Corequisite: MAT 290F)

ELE 211S CIRCUIT THEORY II

II – 7 3 1½ 1 9

Complex frequency, network functions, poles and zeros, frequency response, the S plane. Resonance phenomena. Magnetically coupled circuits. Impedance transformations. Two-port networks. General network theorems. Transfer functions. Orthogonal functions and the Fourier series and transform. Laplace transforms. Linear systems. Pole zero plots. Texts: Close *The Analysis of Linear Circuits*; Lathi *Signals, Systems and Communications.* (Prerequisites: ELE 210F, ELE 200F)

ELE 221S ELECTRIC AND MAGNETIC FIELDS

II – 7 3 – 2 8

Static electric and magnetic fields. Properties of dielectric and magnetic media. Particle dynamics in electric and magnetic fields. Time-varying fields. Development of Maxwell's equations and interpretation. Text: Hayt *Engineering Electromagnetics.* (Prerequisites: ELE 200F, ELE 210F, MAT 290F)

ELE 231S ELECTRONIC CIRCUITS A

II – 7 2 1½ 1 8

A global view of electronics and electronic systems considering the following topics: The ideal diode. Vacuum tubes, semiconductors, PN junctions. Bipolar transistors. DC amplifiers. Large signal switching. Text: Oldham & Schwartz, *An Introduction to Electronics*, Holt, Rinehart & Winston, 1972. (Prerequisites: ELE 210F, MMS 221F. Corequisite: ELE 211S)

ELE 250F ELECTRIC CIRCUITS

II – 5 3 3 – 8½

Fundamental Laws. Electrical elements. Analysis of simple linear circuits. First- and second-order circuits. Simple nonlinear circuits. Formulation of circuit equations. Circuits in the sinusoidal steady state. Harmonics and Fourier analysis. Frequency domain analysis. Time domain analysis. Laplace transforms. Multiterminal circuits. Text: Wing, *Circuit Theory with Computer Methods*, Holt, Rinehart & Winston, 1972. (Prerequisite: ELE 150S. Corequisite: MAT 295F)

ELE 270F CIRCUIT THEORY AND MEASUREMENTS

II – 3 3 1½ 1½ 10

Experimental laws. Techniques of circuit analysis. Duality. Source-free RL and RC circuits. The unit-step forcing function. The sinusoidal forcing function. Phasors. The sinusoidal steady-state response. Average power and rms values. Resonance. Polyphase circuits. Magnetically-coupled circuits. Text: Hayt, Kemnerly, *Engineering Circuit Analysis*, McGraw-Hill 2nd ed. (Prerequisite: ELE 121S)

ELE 271S ELECTRICAL ENGINEERING

II – 4 (elective) 3 1½ 1 8

Analysis of single-phase and three-phase circuits; principles of ac and dc machines; introduction to vacuum-tube and solid-state devices; basis of digital computation and analogue simulation; electronic measurements applied to industrial processes. Text: Del Toro, *Fundamentals of Electrical Engineering*, Prentice Hall. (Prerequisite: ELE 121S or ELE 150S or equivalent)

ELE 272S ELECTROMECHANICAL ENERGY CONVERSION

II – 3 3 1½ 1½ 8

Ferromagnetism and magnetic circuits. The transformer. Principles of electromechanical energy conversion. Activators. Steady-state operation of dc and ac machines. (Prerequisite: ELE 270F)

ELE 310F SYSTEM AND SIGNAL ANALYSIS A

III – 7 3 – 2 9

System representation and analysis. State variable formulation. Review of Fourier series, Fourier transform, and Laplace transform. A study of the behaviour of continuous-time linear systems using transform methods. Transfer functions, frequency response, Bode diagrams, energy density spectrum. Stability, Routh-Huriwitz, Nyquist, root locus. Signal flow graphs. Texts: Lathi, *Signals, Systems and Communication*; Dorf, *Modern Control Systems*. (Prerequisite: ELE 211S)

ELE 311S SYSTEM AND SIGNAL ANALYSIS B

III – 7 3 1½ 1 9

Convolution integral and methods. Communication systems, multiplexing, modulation, and sampling. Stochastic processes, stationarity, convolution, correlation, power spectrum, spectral analysis. Texts: Lathi *Signals, Systems and Communication*; Davenport *Probability and Random Processes*. (Prerequisite ELE 310F)

ELE 312F ELECTROMECHANICAL SYSTEMS I

III – 7 3 1½ 1 9

Review of Maxwell's equations, energy, force, conservation of energy. Magnetic circuit analysis, linear and non-linear. Ideal transformer and transformer design. Single phase and three phase transformers. Electromechanical energy conversion principles. Rotating machines and their construction. Texts: Slemon *Magneto-Electric Devices*; Fitzgerald, Kingsley, Kusko *Electric Machinery, 3rd ed.* (Prerequisites ELE 211S, MEC 205F.)

ELE 313S ELECTROMECHANICAL SYSTEMS II

III – 7 3 1½ 1 9

Generalized machine parameter evaluation, reduction. Steady-state and dynamic performance of DC, induction and synchronous machines. Introduction to multi-machine systems. Texts: Slemon *Magneto-Electric Devices*; Fitzgerald, Kingsley, Kusko *Electric Machinery*. (Prerequisite ELE 312F)

ELE 314S DIGITAL SYSTEMS

III – 7; III – 5e (elective) 2 1½ – 6

Introduction to logic, propositional logic, Boolean algebra, basic operations, truth tables, fundamental algebraic manipulations. Storage elements, flip-flops and registers, register transfer operations. Design of counters, encoders, decoders. Fan-in, fan-out. Number representation and coding, 1's and 2's complement, BCD, parity. Designs for adders, multipliers, dividers. Memory techniques, read/write, read only, volatile, non-volatile magnetic core memory. Design methods for control and data flow in simple systems such as sampled data communications, feedback digital controller. Text: T. L. Booth, *Digital Networks and Computer Systems*. (Prerequisites ELE 201S, ELE 231S or equivalent)

ELE 320F FIELDS AND WAVES

III – 7 2 1½ 1 8

Propagation of plane waves. Reflection of waves at plane boundaries. Guided waves. Transmission line theory. Smith chart. Radiation from antennas. Diffraction and scattering. Introduction to holography. Text: Skilling *Fundamentals of Electric Waves*. (Prerequisite ELE 221S)

ELE 331S ELECTRONIC CIRCUITS B

III – 7 3 3 – 10

P-N Junction diode models: advanced applications of p-n junction diodes. Temperature dependence of diode characteristics and methods for compensation. JFET's and MOSFET's, characteristics, biasing, models, circuits. Bipolar transistors, basic concepts, fabrication, power gain, basic configurations, Ebers and Moll model, circuit models, single and multistage amplifiers. Feedback amplifiers, oscillators. Narrow and wide band amplifiers. Introduction to switching circuits. Text: Angelo *Electronics: BJT's, FET's, and Microcircuits*. (Prerequisite ELE 231S. Corequisite ELE 336S)

ELE 335F PHYSICAL ELECTRONICS A

III – 7; III – 8 (elective) 2 1½ – 6

Quasi-Free electron theory of solids. Electron emission. Structure and basic properties of semiconductors. Carrier transport. P-N junction diode, tunnel diode, Schottky diode, Gunn diode. Text: Perry and Fanin *Physical Electronics*. (Prerequisites MMS 221F, ELE 231S)

ELE 336S PHYSICAL ELECTRONICS B

III – 7 2 – 1½ 6

Unipolar transistors: basic types: junction-gate, M.I.S., and thin-film F.E.T.'s theory, circuit models. Bipolar transistors: fundamental theory, injection efficiency, base transport efficiency, small-signal low-frequency models. Charge storage models. High-frequency, small-signal analysis and circuit models. Fundamentals of integrated circuits: fabrication theory and technology: diffusion, epitaxy, oxide masking; capacitors, resistors, bipolar and unipolar transistor integration. Examples. Photoelectronics solid-state optoelectronic phenomena: photoconductive, photovoltaic and pn junction radiation detection. Vacuum photoelectronics: image orthicon, vidicon, image storage and intensification. (Prerequisite ELE 335F)

ELE 350F PHYSICAL ELECTRONICS I

III – 5cs, 5e, 5p, 8 (elective) 2 1½ – 7

Courses 350F and 352S deal with the basic physics underlying the operation of semiconductor devices. Band theory of solids, metals, semiconductors, insulators, mobility and conductivity. Drift and diffusion currents. Theory of pn junctions. Tunnel and avalanche diodes. Bipolar transistors. (Prerequisite PHY 281S. Exclusion ELE 335F)

ELE 351F ELECTRONIC CIRCUITS I

III – 5cs, 5e; 5p (elective) 2 1½ – 8

A communication system, an analog computer and a digital computer, as examples of electronic systems. Identification of basic circuit functions. Passive RLC circuits as load and coupling circuits in both the time domain and the frequency domain. Ideal active elements: Amplifiers, operational amplifiers, controlled sources, logic elements and memory elements. Nonideal behaviour of amplifiers and their classification. Ideal and real diodes with applications. Qualitative description of pn junctions. Characteristics of bipolar transistors in the normal mode. Biasing design of transistor circuits. Derivation of 1st order equivalent circuits. Design of simple transistor amplifier circuits. (Prerequisite ELE 250F. Exclusion ELE 231S)

ELE 352S PHYSICAL ELECTRONICS II

III – 5e, 5p (elective) 2 1½ – 7

Recombination-generation processes. Further properties of the bipolar transistor. Junction field effect transistors; MOS transistors. Fundamentals of integrated circuits. Photoconductivity. Solid state optoelectronic phenomena. Vacuum photoelectronics: image orthicon, vidicon. (Prerequisite ELE 350F. Exclusion ELE 336S)

ELE 353F COMPUTER ORGANIZATION

III – 5cs; IV – 5e (elective) 3 1½ 1 10

Digital system design principles. Registers and data flow. Computer structure, machine language instruction execution and sequencing, addressing techniques. Digital representation of data. Arithmetic operations. Memory hierarchy, direct and associative addressing. I/O techniques and channels. Some case studies of actual machines. Introduction to reliability. The laboratory will consist of topics from simulation studies of systems using GPSS, experiments involving logic systems, and small computers. Text: Lewin, *Theory & Design of Digital Computers.* (Exclusion ELE 441S)

ELE 354S ELECTRONIC CIRCUITS II

III – 5e 3 3 – 10

Design of AC coupled transistor stages, DC amplifier. Integrated circuit design limitation. Design of multitransistor circuits from configuration point of view. Hybrid II equivalent circuit models. Design of audio amplifiers, wideband amplifiers, tuned amplifiers. Negative feedback concepts and oscillators. Field effect devices and applications. Transistors as switching elements. Design of simple logic and memory circuits. (Prerequisite ELE 351F. Exclusion ELE 331S)

ELE 355F SYSTEM AND SIGNAL ANALYSIS I

III – 5cs, 5e, IV – 5cs 3 – 1 8

Signal representation by classical Fourier series and Fourier integral: orthogonality and completeness, pointwise and mean square convergence, inversion techniques, energy relations and time-bandwidth trade-off. Applications to circuits, sampling and modulation. Laplace transform: inversion techniques, application to transient analysis and frequency response of systems described by ordinary differential and differential-difference equations. Additional topics selected from: distributions, z-transform, discrete Fourier transform. (Prerequisites ELE 250F, MAT 295F, MAT 289S, or equivalent. Most assignments require use of the computer. Exclusion ELE 310F)

ELE 356S SYSTEM AND SIGNAL ANALYSIS II

III – 5e 3 1½ – 8

Modelling of physical systems. State representation of dynamic systems as vector matrix differential and difference equations. Linearization. Controllability and observability. Steady-state performance and stability analysis for constant, linear systems employing Bode diagrams, root loci, Routh and Nyquist criteria. Synthesis of elementary feedback compensators. (Prerequisite ELE 355F. Exclusion ELE 311S)

ELE 357F ELECTROMAGNETIC FIELDS

III – 5g; III – 5e, 5p (elective) 3 1½ 1 9

Wave propagation in linear electromagnetic media. Maxwell's equations and constitutive relations. Plane waves in dielectric and conducting media. Wave polarization. Poynting vector. Transmission lines. Smith Chart. Dielectric and optical waveguides. Retarded potentials. Small loop and short dipole antenna. Wave propagation in anisotropic media. (Prerequisite ELE 221S, PHY 280F, MAT 289S)

ELE 358S CONTROL SYSTEMS

III – 5a, 5nt, 5p (elective) 3 1½ 1 9

As prescribed for ELE 356S. The tutorial will be used to provide problem solving competence in a few of the topics missing in the background of registrants who have not taken ELE 355F. (Prerequisite ELE 250S or ELE 211S with good standing. Exclusion ELE 355F)

ELE 360S ELECTRONIC CIRCUITS II

III – 5cs 3 1½ – 8

As prescribed for ELE 354S with special laboratory exercises.

ELE 405F SWITCHING THEORY

IV – 7 2 – 2 8

Boolean algebra, boolean functions. Design and minimization of combinational networks. Sequential machines, finite state models, synthesis, state assignment, state reduction. Synthesis and analysis of asynchronous sequential machines. Combinations of sequential machines. Identification. Text: Kohavi, *Switching and Automata Theory.* (Prerequisite ELE 314S)

ELE 410F CONTROL SYSTEMS I

IV – 7 2 1½ 1 8

Review of steady-state and dynamic performance analysis, stability analysis and Bode diagrams. Linear compensation design. Process control design. Frequency and time domain analysis of nonlinear controllers; design of relay control systems. (Prerequisite ELE 311S)

ELE 411S CONTROL SYSTEMS II

IV – 7 2 1½ 1 8

Vector-matrix differential equations as models for physical systems. Solution methods; analytic, analog and digital simulation. Eigenvalues, eigenvectors; modal theory. Controllability; design of modal controllers. Observability; design of dynamic observers. Design using optimal control methods. (Prerequisite ELE 410F. Exclusion ELE 450F)

ELE 412F NETWORK THEORY

IV – 5e, 7 (elective) 3 – 2 8

Network analysis and network functions. Introduction to active filters. Properties and synthesis of LC and RC one-ports. Positive real functions, testing, realizations. Properties and synthesis of lossless singly- and doubly-terminated two-ports. Synthesis of approximations to ideal filters. Text: Humphreys, *The Analysis, Design and Synthesis of Electrical Filters.* (Prerequisites ELE 311S, ELE 201S)

ELE 413F POWER SYSTEM ANALYSIS

IV – 7 2 1½ 1 8

Transmission lines, parameters and representation. Power system components. Behaviour of elementary power systems under normal and fault conditions. Texts: Stevenson *Elements of Power System Analysis* 2nd ed.; Elgerd, *Electric Energy Systems Theory.* (Prerequisite ELE 313S)

ELE 414S POWER SYSTEM CONTROL

IV – 7 2 1½ 1 8

Load flows. Optimization problems. Voltage control. Relay protection. Stability. Reliability and reserve requirements. Texts: Stevenson *Elements of Power Systems Analysis*; Elgerd, *Electric Energy Systems Theory*. (Prerequisite ELE 413F)

ELE 416F COMMUNICATION SYSTEMS A

IV – 7 2 3 – 8

Spectral analysis, use of Fast Fourier Transforms for simulation, random variables and processes, AM and FM systems, vestigial side band, single side band, noise in modulation systems. Text: Taub & Schilling, *Principles of Communication Systems*, McGraw-Hill. (Prerequisite ELE 311S)

ELE 419F ELECTROMECHANICAL SYSTEMS III

IV – 7 2 1½ 1 8

Steady state and dynamic operation of both AC and DC industrial drive systems. Design of conventional and solid state control including position velocity and torque control applications. System monitoring and protection including central computerized control. Introduction to elementary machine and machine system design. Text: Kusko, *DC Machine Drive Systems*; Jones, *Unified Machine Theory*. (Prerequisite ELE 313S. Corequisite ELE 410F)

ELE 420F ELECTROMAGNETIC THEORY

IV – 7 2 – 2 8

Radiation from wire antennas, antenna arrays and continuous current distributions. Wave scattering. Antenna system design. Wave polarization. Waveguide resonators. Circular waveguides. Reciprocity. Self and mutual impedance of current-carrying conductors. Wave propagation in the ionosphere. Text: Jordan & Balmain, *Electromagnetic Waves and Radiating Systems* 2nd ed. (Prerequisite ELE 320F)

ELE 421S MICROWAVES & OPTICS

IV – 7 2 1½ 1 8

Propagation of waves in single and multiple dielectric films. Antenna arrays. Microwave communication systems. Formal solution of boundary value problems; Green's functions. Scattering by conductors. Diffraction by apertures. Fourier optics and holography. (Prerequisite: ELE 320F)

ELE 430F ELECTRONIC CIRCUITS C

IV – 7 2 3 – 8

A design course considering the following topics: Bias design. DC coupling techniques. Multistage amplifiers. Frequency effects. Narrow band amplifiers. Feedback Oscillators. Active filters. Modulation/Demodulation. Power amplifiers. Low noise techniques.

Texts: Ghausi *Electronic Circuits*; Millman and Halkis *Electronic Devices and Circuits*. (Prerequisites ELE 231S, ELE 331S, ELE 211S, ELE 311S)

ELE 431S INTEGRATED CIRCUITS

IV – 7, IV – 5e (elective) 2 3 – 8

Design of integrated circuits with particular emphasis on the interaction between device and circuit design. Linear integrated circuit design techniques and limitations. Digital integrated circuits design evolution leading to large scale integration. (Prerequisites for IV-7: ELE 336S, ELE 331S; for IV-5e: ELE 352S, ELE 354S)

ELE 432S SWITCHING CIRCUITS

IV – 7, 5cs, 5e (elective) 2 3 – 8

A design course in electronic switching circuits. Static and dynamic characteristics of semiconductor devices as switching elements. Transistor multivibrators. Integrated circuit logic families. Linear and non-linear waveshaping techniques. Flip-flops, registers, counters, encoders, memories. (Prerequisites for IV-7: ELE 314S, ELE 331S; for IV-5: ELE 354S, ELE 314S)

ELE 433S POWER SEMICONDUCTOR CIRCUITS

IV – 7, 5e (elective) 2 3 – 8

Power semiconductor switches. Circuit transients. Design of inverter, converter and rectifier circuits with particular applications to DC and AC motor speed control and frequency conversion. (Prerequisites ELE 211S, ELE 331S, ELE 314S)

ELE 435F SEMICONDUCTOR PHYSICS

IV – 7, IV – 5e (elective) 2 1½ 1 8

Elements of crystallography. Dynamics of crystal lattice. Quantum theory of electrons in periodic lattics. Statistics of electrons, holes and impurity states. Transport theory. Scattering processes. Excess carriers in semiconductors. Recombination mechanisms. Text: McKelvey, *Solid State and Semiconductor Physics*. (Prerequisite: ELE 336S)

ELE 437S QUANTUM ELECTRONICS

IV – 7, IV – 5e (elective) 3 1½ – 8

The purpose of the course is to develop the understanding of the principles of operation of lasers and masers and to provide a description of typical devices of that category. The major topics treated are: Fundamental concepts of quantum mechanics. Schroedinger equation, and their application to the theory of absorption and emission of radiation. Population inversion and amplification by stimulated emission. Pumpng schemes and construction of optical and microwave amplifiers and oscillators. Non-linear behaviour of materials at optical frequencies and the use thereof in optical detectors and modulators. Text: Yariv, *Quantum Electronics*. (Prerequisites ELE 320F, ELE 336S)

ELE 440F COMPUTER PROGRAMMING AND DATA STRUCTURES

IV – 7, 5e (elective) 2 – 2 8

Review of machine structure and machine language programming. Assembler language. Assembler design searching and sorting. Macro language and macro processors. Design of loaders. High level languages: PL/I. Formal systems: formal grammars, BNF. Compiler design. Operating systems. Text: Donovan, *Systems Programming.* (Prerequisite: ELE 314S or equivalent)

ELE 441S COMPUTER ORGANIZATION

IV – 7, 5e (elective) 2 3 – 8

The design of digital computers including the following topics: Control unit organization: series-parallel operation, control unit logic, micro-programmed control units. Arithmetic units: addition, subtraction, multiplication, division, floating point arithmetic. Storage systems: core memory, semiconductor memory, drums, discs, tapes, associative memory. I/O: control, paper tape, I/O organization. High parallel systems: pipelined systems, array processors. Text: Lewin, *Theory and Design of Digital Computers.* (Prerequisite: ELE 314S. Exclusion: ELE 353F)

ELE 445S BIOMEDICAL ENGINEERING

IV – 7, 5e (elective) 3 1½ – 8

An introduction to some aspects of the interaction between engineering and medicine, given by the staff of the Institute of Bio-Medical Electronics and Engineering: Basic Anatomy and Physiology, Biological communication processes, Biological feedback and control, Bio-medical instrumentation, Cardiovascular measurements, Radiation diagnosis. Text: Selkurt *Physiology.* (Prerequisites ELE 331S and ELE 310F or equivalent)

ELE 447S ILLUMINATION

IV – 7 3 1½ – 8

The course deals in general with the engineering problems which relate to the effective use of light (physical, physiological and psychological) in the everyday life of man. The topics covered include: The nature and characteristics of light; The production of light: incandescence and luminescence; The human eye, visual processes, and visual phenomena; radiometric and photometric units and laws; photometric measurements; calculation of photometric quantities; design of the visual environment: principles which relate to visual comfort and efficiency; colour and colorimetry; light sources – circuits and controls; visual problems at low light levels e.g. street lighting. Text: Stevens *Building Physics – Lighting.*

ELE 448F APPLIED OPTICS

IV – 7 2 1½ 1 8

Principles of ray optics and their applications to the design and analysis of optical systems including the theory of aberrations. Wave optics of isotropic and birefringent media, interference phenomena and diffraction limits of optical systems. Text: Longhurst, *Geometrical and Physical Optics*, Longman's (Student ed.). (Prerequisite: ELE 320F)

ELE 449F ENGINEERING AS A PROFESSION

IV – 7 2 – 2 8

The course will consist of a combination of lectures and seminars on the role of the Engineer in society. Topics to be discussed include: 1. Why does society not yet consider the engineer to be fully professional? 2. Does the engineer have a proper set of values? 3. Why does there not exist a philosophy of engineering? 4. Should the engineer bear the sole responsibility for the social consequences of his engineering projects? 5. What is the role of the engineer in such public issues as pollution, unemployment, urban development, etc.? 6. The role of the engineer as an entrepreneur.

ELE 450F TECHNIQUES OF SYSTEM THEORY

IV – 5e (elective) 2 1½ – 8

An advanced undergraduate course in multivariable system theory. Linear differential equations over linear spaces. System theory fundamentals of constant and time-varying dynamical systems, representations and realizations, equivalence, maps, controllability, observability, Stability concepts, bounded and in the sense of Lyapunov, perturbation results. Computational methods. Applications such as pole assignment, observer theory, vector frequency response methods. Text: Desoer, *Notes for A Second Course on Linear Systems.* (Prerequisite: ELE 356S, ELE 358S or ELE 311S with good standing)

ELE 452F ELECTRONIC CIRCUITS III

IV – 5e (elective) 2 3 – 8

A design course in electronic circuits including: Multistage amplifiers. Feedback amplifiers. Oscillators. Wideband amplifiers. Tuned amplifiers. Low noise amplifiers. Power amplifiers. Active filters. Distributed RC networks. Elementary analysis of nonlinear electronic circuits. Use of functional electronic building blocks, e.g., operational amplifiers, multipliers, phase locked loops, etc., in instrumentation applications. Computer aided circuit design is used throughout the course. (Prerequisite: ELE 352S, ELE 354S. Exclusion: ELE 430F)

ELE 453F COMMUNICATION SYSTEMS I

IV – 5cs, 5e (elective) 2 – 1 8

Spectral analysis, use of Fast Fourier Transforms for simulation. Random processes. AM and FM systems. Vestigial side band. Single side band. Pulse modulation systems. Noise in modulation systems. Text: Taub & Schilling, *Principles of Communication Systems*, McGraw Hill. (Prerequisite: ELE 356S. Exclusion: ELE 416F)

ELE 454S COMMUNICATION SYSTEMS II

IV – 5e (elective), IV – 7 (elective) 2 3 – 8

Pulse modulation systems, delta modulation, noise in pulse modulation systems, phase locked loops, data transmission, matched filters, information theory and coding. The laboratory will include design projects. (Prerequisite: ELE 416F or 453F)

ELE 455S TECHNIQUES OF OPTIMIZATION

IV – 5cs, 5e (elective) 3 – 1 8

Calculus of variations. Maximum Principle. Linear and non-linear mathematical programming; dynamic programming; queuing theory; some problems in control theory; Monte Carlo methods. Applications will be drawn from engineering practice. (Prerequisite APM 393F, MAT 390S)

ELE 457S MICROWAVE ELECTRONICS

IV – 7; IV – 5e (elective) 2 1½ 1 8

A design course considering the following topics: Stability criteria for active electromagnetic systems. Wave interaction in active media: Gunn diodes, IMPATT diode, Solid-state lasers. Coupled Systems: Travelling wave tube, backward wave oscillator, acousto-electric amplifier. Parametric Interactions: harmonic generation and mixing, parametric amplifiers. Microwave acoustics: bulk wave transducers, acousto-optic modulator. Passive components: resonators and couplers. Text: Soohoo, *Microwave Electronics*; Yariv, *Introduction to Optical Electronics*. (Prerequisite, ELE 320F or ELE 357F)

ELE 459F SWITCHING THEORY

IV – 5e (elective) 2 – 1 7

Design of combinational switching circuits. Minimization techniques. Functional decomposition. Threshold networks. Iterative arrays. Finite state sequential machine model. Design of synchronous and asynchronous machines. Sequential machine decomposition. Linear sequential machine applications. Text: Z. Kohavi, *Switching and Finite Automata Theory*, McGraw-Hill.

ELE 470F ELECTRICAL SYSTEMS

IV – 8 3 3 – 9

Electrical circuits, components, machines, sensors, transducers, instrumentation and controls with emphasis on practical applications, including heating and melting. Text: Lister, *Electric Circuits and Machines* (4th ed.).

ELE 471F INSTRUMENTATION DESIGN

IV – 3 3 1½ – 10

This course includes the theory, methods, and instrumentation required for the measurement of variables of interest to mechanical engineers; e.g., strain, liquid flow, airflow, vibration, etc. Also included is a discussion of transducers required to convert these variables to electrical signals, and the use of electronic modules in the design of equipment to process these signals. The interfacing of these modules with analogue and digital recording and processing devices will also be covered.

ELE 496F THESIS

IV – 7 — — — 16

Each student in Electrical Engineering is required to write a thesis on an approved topic of his choice under the supervision of an academic staff member of the department. The thesis may involve experimental or other project-related activities. The weight to be attached to the thesis depends on the size of the thesis topic and must be approved by the student's thesis supervisor.

Further details are available from the Electrical Engineering Enquiry Office, G.146. (Prerequisite: completion of all third year technical courses. Exclusions: ELE 497S, ELE 498F, ELE 499S)

ELE 497S THESIS

IV – 7 — — — 16

Same as ELE 496F, but in spring term. (Prerequisite: completion of all third year technical courses. Exclusions: ELE 496F, ELE 498F, ELE 499S)

ELE 498F THESIS

IV – 7 — — — 8

Same as ELE 496F, but of smaller weight. (Prerequisite: completion of all third year technical courses. Exclusions: ELE 496F, ELE 497S)

ELE 499S THESIS

IV – 7 — — — 8

Same as ELE 498F but in spring term. (Prerequisites: completion of all third year technical courses. Exclusions: ELE 496F, ELE 497S)

DEPARTMENT OF GEOGRAPHY

GGR 311S SEDIMENTARY PROCESSES

IV – 2A, 2C 1 1 – 6

Basic processes of sediment erosion, transportation, and deposition that operate during landscape evolution. Principles of clastic sedimentation, origin of sedimentary particles, particle properties, behaviour of particles in fluids, primary sedimentary structures, sedimentary sequence. Tectonics and sedimentation, geosynclines, continental geomorphology. Modern and ancient depositional environments, environment determination, facies analysis, palaeogeography. Analytic techniques used in sediment studies.

DEPARTMENT OF GEOLOGY

GLG 120F PRINCIPLES OF PHYSICAL GEOLOGY

II – 2, III – 5g 2 2 1 9

Principles of physical geology and the evolution of the earth as a planet. Topics include the composition and form of minerals and rock bodies, the deposition of sediments by rivers and oceans, the origin of mountain systems and the development of global structures. Air photographs, geological maps and cross sections are used in studying the effects of geologic processes. A field trip is taken in October.

J. B. Currie

GLG 122S PRINCIPLES OF HISTORICAL GEOLOGY

II – 2, III – 5g 2 2 1 9

A lecture-laboratory course that traces the history of the earth and its changing environment from the sequence of physical and biological events revealed in the rock record. Paleontology and concepts of geologic environments and time are emphasized in the laboratory and in the field. (Prerequisite GLG 180S or 120F)

G. Norris

GLG 180S APPLIED PHYSICAL GEOLOGY

I – 1, 2, 3, 4, 5, 6, 7, 8 (elective) 3 1½ – 8

Fundamentals of physical geology as related to engineering problems and practice. Configuration of the planet and the effects of external and internal processes that act upon it; influence of earth processes as a factor in the design of engineering structures. Students will gain a knowledge of earth materials – their occurrence and uses.

S. D. Scott

GLG 220 MINERALOGY

II – 2 2 4 – 9, 2 4 – 9

A first course in mineralogy and crystallography; the study of minerals or inorganic chemicals in the earth's crust; the principles of crystal chemistry and its use in mineralogy; the relationship between structures and physical properties of minerals; the use of the polarizing microscope; the theory and practice of optical mineralogy; the occurrence and classification of minerals, and their identification both micro- and macroscopically. (Prerequisite: CHM 100F, prerequisite or corequisite: GLG 120F/180S, GLG 122S)

D. H. Gorman, J. C. Rucklidge

GLG 221S GEOLOGICAL DATA PROCESSING BY COMPUTER

II – 2 (elective) 1 3 – 8

Applied mathematics, probability and statistics for processing geological data using computer methods. (Prerequisites APS 100F, GLG 120F/180S, GLG 122S. Corequisites GLG 120F, GLG 122S)

F. G. Smith

GLG 280S APPLIED PHYSICAL GEOLOGY

II – 1 2 1½ 1 8

A course similar to GLG 180S, but with alternate laboratory assignments.

GLG 320 PETROLOGY

III – 2 2 3 – 8, 2 3 – 8

The principles of petrology with major emphasis on igneous and metamorphic rocks; examination of criteria used for the classification of major rock types; the interpretation of rocks as indicators of crustal and mantle processes. Laboratory work covers the application of mineralogical data to the identification and description of igneous sedimentary and metamorphic rocks.

J. J. Fawcett

GLG 321F STRATIGRAPHY AND SEDIMENTATION

III – 2 1 3 – 8

The properties and classification of sediments and strata. Sedimentary environments and tectono-environmental concepts in stratigraphy; the influence of global tectonics on local stratigraphy. Stratigraphy applied to mineral exploration. (Prerequisites GLG 220, GLG 222)

F. W. Beales

GLG 322 TECTONICS

III – 2 1 3 – 8, 1 3 – 8

Geometry of existing deformational structures in the earth's crust and reconstruction of their mechanical development. Application of rock mechanics to interpretation of geologic structures. Laboratory work emphasizes methods of structural analysis. (Prerequisite GLG 220. Corequisite GLG 321F)

W. M. Schwerdtner

GLG 324 PHYSICAL GEOCHEMISTRY

III – 2 3 – – 8, 3 – – 8

Chemical thermodynamics, phase diagrams, electrochemistry, solution chemistry and ionic equilibria, kinetics with examples from natural and experimental mineral systems at a wide range of temperatures and pressures. (Prerequisite GLG 220)

S. D. Scott, G. M. Anderson

GLG 325F FIELD CAMP I

II – 2A, C – – – –

A field course in the northern Appalachians emphasizing elementary mapping methods and basic field techniques applicable to structural-stratigraphic studies. The Taconian orogenic belt in Quebec and the adjacent craton will be examined in the field as a prelude to more intensive study and laboratory work in 300-series courses. (Prerequisite GLG 220)

A fee, currently $45, is charged to cover part of cost of transportation and accommodation.

GLG 327S GEOLOGY OF THE CANADIAN SHIELD

III – 2 13 – 8

The stratigraphy, tectonic divisions and economic aspects of the Precambrian. Laboratory study of geological maps and reports; examination of typical rock suites in hand specimens and thin sections. (Prerequisite GLG 321F. Corequisite GLG 322)

A. M. Goodwin

GLG 421 MINERAL DEPOSITS

IV – 2 23 – 8, 23 – 8

Systematic mineralogy and phase equilibria of ore minerals. Identification of ore minerals in polished section. Geochemistry of ore-forming processes. Case-history study of important ore deposits and discussion of their genesis. Synthesis of geologic techniques applied in designing exploration programs for new deposits. (Prerequisites GLG, 320, 324)

A. J. Naldrett

GLG 422 EXPLORATION GEOCHEMISTRY

IV – 2 23 – 8, 23 – 8

Geochemical and geological aspects of mineral exploration, including characterization of target, nature of detectable halos, surrounding target, typical survey methods and chemical analysis of materials obtained, statistical evaluation of data and elementary decision-making techniques. (Prerequisites GLG 220, 324)

S. E. Kesler, J. C. Van Loon

GLG 425F FIELD CAMP II

III – 2 ––––

A two-week field camp held following the conclusion of the annual Third Year examinations. Instruction and experience in geological mapping. A fee, currently $90, is charged to cover part of the costs of meals and accommodation. (Prerequisites GLG 320, GLG 322)

GLG 428F PETROLEUM GEOLOGY

IV – 2 23 – 8

Application of geology to exploration for oil and gas in sedimentary basins; study of geologic conditions that govern petroleum entrapment; fluid flow through porous media; discussion of non-renewable energy-resources. (Prerequisite: GLG 321F)

J. B. Currie

GLG 429S GROUNDWATER GEOLOGY

IV – 2 (elective) 2 3 – 8

Geological aspects of groundwater occurrence and migration of fluids in subsurface strata. Groundwater composition and its variation in drainage basins in Canada. Exploration for and utilization of groundwater. (Prerequisite GLG 321F)

J. B. Currie

GLG 499S THESIS

IV – 2A – 6 – 8

Each student is required to prepare a thesis on an approved subject. Instructions will be issued by the Chairman of the Geological Engineering Course Committee.

DEPARTMENT OF INDUSTRIAL ENGINEERING

IND 200F ELEMENTS OF INDUSTRIAL ENGINEERING I

II – 4 2 – 2 8

History of Industrial Engineering, nature of modern Industrial Engineering, mathematical models of systems as a central concept of the discipline, consequences for curriculum design. Examples of case histories to illustrate idea of mathematical models of systems. Some models of wide applicability – linear programming and stochastic models with illustrations of their use in production and inventory models and in resource allocation.

B. Bernholtz

IND 201S ELEMENTS OF INDUSTRIAL ENGINEERING II

II – 4 2 – 2 8

A broad survey of the principles of productivity management including methods study and work simplification, plant location and facilities planning, value analysis, work measurement, production and inventory control, quality control, resources management and organization theories.

J. Vanderheyden

IND 202F COMPUTERS AND PROGRAMMING I

II – 4 2 – 2 8

Computer organization; machine and assembly language; basic data structures and their applications; fundamental algorithms, computer system architecture; computer program engineering. The course emphasizes the formulation of complete, correct, and efficient algorithms for the solution of problems drawn from engineering, computer science, information processing and operational research. Practical work includes laboratory exercises and program design assignments, involving coding in /370 Assembler and PL/1.

G. R. Comrie

IND 301F OPERATIONAL RESEARCH I

III – 4, IV – 2B, 8 (elective) 2 – 2 8

An introduction, using simplified case studies, to the methodology, techniques and applications of operational research. Emphasis will be placed on developing an understanding of operational research as a rational approach to decision-making. Models to be presented and discussed will include ones for decision-making regarding inventory, replacement, allocation, scheduling and project management. (Prerequisites MAT 294S, STA 282S/STA 292S. Exclusion IND 331S)

A. A. Cunningham

IND 302S OPERATIONAL RESEARCH II

III – 4, IV – 2B, 8 (elective) 2 – 2 8

A continuation of IND 301F with emphasis on problems where more complex models are required. The focus is on the constructive interaction between problem identification and mathematical solution techniques. Models discussed include multi-period and multi-item inventory management, decision analysis, integer programming and dynamic programming. (Prerequisite IND 301F. Exclusion IND 331S)

J. S. Rogers

IND 303S COMPUTERS AND PROGRAMMING II

III – 4 2 – 2 8

A continuation of Course IND 202F with further emphasis on computer program engineering, covering the following topics: information storage and retrieval, file organization, input/output processing; data structures, list processing; introduction to functions and facilities of operating systems with specific reference to System/370; efficiency; special purpose languages. Problems chosen from engineering, operational research, and data processing, will involve coding in PL/1 and assembler. (Prerequisite IND 202F or equivalent)

R. W. P. Anderson

IND 304F INDUSTRIAL RELATIONS

III – 4 2 – 1 8

A discussion of trade unions, labour legislation and the collective bargaining process. (Prerequisite ECO 281/ECO 100. Exclusion ECO 344)

A. Kruger

IND 305F HUMAN FACTORS IN MAN-MACHINE SYSTEMS

III – 4 2 3 – 8

The course will be concerned with Human Factors from two points of view: (a) the anatomical, physiological and psycho-physical factors underlying the design of specific man-machine interfaces in specific environments; (b) the psychological factors involved in the determination of the allocation of function between men and machines in the overall system, specifically information processing capacity, acquisition and retention of skill, adaptability and stress. The laboratory period will illustrate and emphasize experimental methods in these areas.

P. J. Foley, J. Senders

IND 331S OPERATIONAL RESEARCH

III – 5cs, IV – 5e 2 – 2 7

Processes of model building and solution. Problems of reliability, allocation, queueing, competition, sequencing, and co-ordination. Mathematical techniques of linear and dynamic programming, branch and bound methods, simulation, activity networks, and Markov processes. (Prerequisites APM 281F/386S/481F; MAT 295F/290F/294S/ MEC 261F; STA 287S/282S/292S/CHE 305F. Exclusions IND 301F, 302S)

J. G. C. Templeton

IND 412F ORGANIZATIONAL BEHAVIOUR

IV – 4 2 – – 8

Individual and group behaviour in work organizations. Relevance to human behaviour and management problems, supervision, communications, motivation and the implementation of change.

IND 413F FUNDAMENTALS OF MANAGEMENT SCIENCE

IV – 4 2 – 1½ 8

The course presents the basic principles of decision-making. It includes such concepts as the changing value of money, the analysis of data by Bayesian inference, the value of accurate information, the use of cardinal utility to represent aversion to risk, and the expression of individual choice by indifference curves. The concepts are illustrated with industrial applications. (Prerequisite IND 302S)

T. A. Lambe

IND 414S APPLICATIONS OF MANAGEMENT SCIENCE

IV – 4 2 – 1½ 8

Algebraic procedures are presented for applying decision theory to processes where uncertainty is characterized by binominal, Poisson and normal distributions. Examples include inspection sampling, equipment replacement, marketing and project cost estimation. (Prerequisite IND 413F)

T. A. Lambe

IND 415F PRODUCTION SYSTEMS

IV – 4 2 – 1½ 8

Introduction to the basic features of production systems and methods of modelling their operation; the material flow, information and control systems. Forecasting, inventories, service level and its measurement, periodic and continuous review inventory models, ABC analysis, aggregate inventory models. The role of inventories in physical distribution. Inventories in manufacturing; requirements planning vs order point control. Planning production capacity. Production control and scheduling. Theory and simulation studies in scheduling. (Prerequisite IND 301F)

J. A. Buzacott

IND 416S ADVANCED INDUSTRIAL ENGINEERING

IV – 4 2 – 1½ 8

Methods of design for operation and control in man-machine systems. Macro-scheduling of manpower and production with discrete and continuous models. Micro-scheduling of jobs and machines. Flow and job shop scheduling. Requirements planning. Demand forecasting and parts explosion for the levels of production. (Prerequisites IND 302S, 303S)

I. B. Turksen

IND 417F STOCHASTIC MODELS

IV – 4 2 – 1½ 8

A course on the analysis of stochastic models in operational research. Review of relevant aspects of probability theory; Poisson processes and renewal processes; queueing models and Markov chains; applications to problems in electronic testing, traffic flows, reliability, inventory, etc. (Prerequisites IND 302S, APM 391F)

M. J. M. Posner

IND 418F SYSTEM SIMULATION

IV – 4 2 – 1½ 8

Computer simulation of systems. Design of continuous and discrete simulation models. Generation of random variates. Information storage and retrieval for simulation. Design of simulation experiments. Application of the theory to the analysis and design of systems for distribution, and education. (Prerequisites IND 302S, 303S)

I. B. Turksen

IND 419S INFORMATION AND OPTIMIZATION

IV – 4 2 – 1½ 8

Efficient transmission of information, coding of messages, capacity of an information channel, error-correcting codes; applications to practical communication systems. Unconstrained optimization in n dimensions: classical and modern algorithms; applications to non-linear programming. (Prerequisite CSC 381F)

J. G. C. Templeton

IND 420S MATHEMATICAL PROGRAMMING

IV – 4 2 – 1½ 8

Formulation of the linear programming problem, the simplex method (review), the revised simplex method, duality and the dual simplex method, postoptimality problems, parametric linear programming. Transportation problems, the fixed charge problem. Flows in networks. Integer linear programming, algorithms for the all-integer and the mixed integer-continuous problem. Fractional linear programming. (Prerequisite IND 302S)

J. Abrham

IND 421F MANAGEMENT INFORMATION SYSTEMS

IV – 4 2 – 1½ 8

Study of information systems in relation to both operational and decision-making activities in an organization; special attention to management planning and control activities. Models of information systems; manpower, logistics, and financial subsystems. Integrated systems. The roles of the information analyst and systems designer; the information processing organization; user implications. The development cycle of information processing systems; project control, implementation, and evaluation; equipment selection and configuration; file structures and software. Terminal-oriented systems. Case study projects. (Prerequisite IND 303S)

S. H. Cohn

IND 423S HUMAN PERFORMANCE IN MAN-MACHINE SYSTEMS

IV – 4 2 3 – 8

The course will cover theoretical and empirical aspects of human performance capabilities in information processing, decision making and control processes, and the loads imposed on the human operator by such tasks.

The laboratory will stress the testing and validation of theories and models of human performance and work load measurement. (Prerequisite IND 305F)

J. Senders

IND 424F THE PSYCHOBIOLOGY OF MAN-MACHINE SYSTEMS

IV – 4 2 3 – 8

The course will examine the man-machine system as a symbiotic relationship, concentrating on the communication links in such a system, with particular attention paid to the nature of biological coding mechanisms; the kinds of coding involved in the organization of sensory and perceptual processes; the structure and functional limitations of symbolic processes and language. (Prerequisite IND 305F)

P. J. Foley

IND 425S DYNAMICS OF GENERAL SYSTEMS

IV – 4 2 – 1½ 8

Development of dynamic models using state space representation for planning and control of industrial, environmental, economic, and social processes. Parameter identification and control methods will be used to study the implications of growth, stability, productivity, energy transfer, and community organization on such systems along with certain topics in population dynamics and adaptive control mechanisms in changing environments. (Prerequisites MAT 294S, MEC 357S. Recommended APM 391F)

E. E. Pickett

IND 497F TERM THESIS

IV – 4 – 6 – 8

Application of the methods and models studied in other Industrial Engineering subjects to an industrial engineering problem. The work will be carried out under the supervision of staff members. A written report is required.

Staff in Industrial Engineering

IND 498S TERM THESIS

IV – 4 – 6 – 8

As IND 497F.

IND 499 THESIS

IV – 4 – 6 – 8, – 6 – 8

Design and analysis of an engineering system to satisfy specified objectives and requirements. This project, extending over two terms, will provide the student with an opportunity to apply the knowledge and techniques of analysis acquired in his other Industrial Engineering subjects. The work will be carried out by students working in small groups, or individually, under the supervision of staff members. (May not be combined with IND 497F or IND 498S.)

Staff in Industrial Engineering

DEPARTMENT OF MATHEMATICS

MAT 185S LINEAR ALGEBRA

I – 5 2 – 1 8

Vector spaces, matrices, linear transformations, eigenvalues, quadratic forms and quadratic surfaces.

P. Quinn, P. A. Sullivan

MAT 186F CALCULUS I

I – 1, 2, 3, 4, 6, 7, 8 2 – 2 6

Limits, differentiation, integration, fundamental theorem, areas, volumes, moments.

Staff in Mathematics and Staff in Engineering

MAT 187S CALCULUS II

I – 1, 2, 3, 4, 6, 7, 8 2 – 2 7

Pressure, work, elementary functions, techniques of integration, series, first order differential equations.

Staff in Mathematics and Staff in Engineering

MAT 188F ALGEBRA I

I – 1, 2, 3, 4, 6, 7, 8 2 – 2 6

Linearity, vectors, complex numbers, linear transformations, matrices, determinants, inverse of a matrix, scalar product.

Staff in Mathematics and Staff in Engineering

MAT 189S ALGEBRA II

I – 1, 2, 3, 4, 6, 7, 8 2 – 2 6

Quadratic forms, orthogonal transformations, eigenvalues, eigenvectors, geometry of lines and planes, linear programming.

Staff in Mathematics and Staff in Engineering

MAT 194F CALCULUS I

I – 5 3 – 2 10

Theory and applications of differential and integral calculus, continuous functions, mean value theorem, elementary functions.

D. K. Sen, L. T. Gardner

MAT 195S CALCULUS II

I – 5 2 – 1 7

Sequences, series, improper integrals, Taylor's theorem, differential equations, functions of several variables and partial derivatives.

D. K. Sen

MAT 280F CALCULUS

II – 1, 2, 6 3 – 2 9

Partial differentiation, maximum and minimum problems, multiple integration, ordinary differential equations and systems. (Exclusion MAT 294S)

P. J. Rooney, R. Luus

MAT 289S COMPLEX VARIABLES

II – 5 3 – 1 8

Complex plane analytic functions, Cauchy's theorem, Taylor and Laurent series, singularities, analytic continuation, contour integration, conformal mapping, and applications.

C. Davis

MAT 290F DIFFERENTIAL EQUATIONS

II – 7 3 – 2 8

Linear ordinary differential equations and systems, series, transform and numerical solutions, nonlinear equations, introduction to partial differential equations.

MAT 293F CALCULUS

II – 2, 3, 4, 8 2 – 2 8

Functions of several variables, partial differentiation, maximum and minimum problems, Taylor series. (Prerequisite MAT 180F, MAT 181S)

D. Masson, J. Abrham, J. Corbett

MAT 294S CALCULUS AND DIFFERENTIAL EQUATIONS

II – 4, 8; II – 2, III – 2 (elective) 2 – 2 8

Ordinary differential equations and systems, multiple integrals, curve integrals. (Prerequisite MAT 293F, Exclusion MAT 280F)

D. Masson, J. Abrham, J. Corbett

MAT 295F CALCULUS III

II – 5 3 – 1 8

Convergence and uniform convergence, linear differential equations, co-ordinate transformations, multiple integrals, line and surface integrals, orthogonal functions.

C. Davis

MAT 390S ALGEBRA

III – 5 3 – – 8

Vector spaces, dual spaces, linear operators and tensors, convexity and extremal problems, introduction to algebraic structures, Boolean algebras, elements of sombinatorics.

MECHANICAL ENGINEERING

MEC 201S DYNAMICS I

II – 3 3 – 1½ 8

Calculus of vectors. Kinematics of bodies in rectinear and curvilinear translation, rotation, and general motion. Spacecraft orbits. Impulse, momentum and moment of linear momentum. Conservative systems. Work-energy relations. Dynamics of motion. Euler's equations. Gyroscopic mechanics. Plane motion. D'Alembert's principle. Virtual work. Introduction to generalized co-ordinates, degrees of freedom, Lagrange equations. Introduction to mechanical vibrations and balancing.

F. P. J. Rimrott

MEC 205F DYNAMICS

II – 7 2 – 1 7

Dimensional units. Vectors. Kinematics, rectinear and angular motion, place motion, projectiles, satellite orbits. Rigid body concept, relative motion with respect to translating and rotating co-ordinates, Euler's equations, gyroscopic effects. D'Alembert's principle. Vibration of mechanical and electrical systems, balancing. Work, energy, power, impulse, momentum. Rockets. Virtual work, Bernoulli's principle, introduction to Lagrange formulation. Reference Book: Vector Mechanics for Engineers – Dynamics – Beer & Johnston.

R. C. Flanagan

MEC 211F MECHANICS OF DEFORMABLE BODIES I

II – 3 3 ¾ 2¼ 10

Simple stress and strain. Concept of stress and strain at a point with treatment in 2-D cases (plane stress and strain). Principal stresses. Mohr's method. Yield criterion. Fatigue. Simple plasticity. Application to analysis of simple machine element (beams, shafts, thin shells, joints, etc.). Properties of mechanical engineering materials (ferrous and non-ferrous metals, polymers).

D. McCammond

MEC 212S MECHANICS OF DEFORMABLE BODIES II

II – 3 3 ¼ 1¼ 8

Generalized equilibrium and compatibility relationships with application to axially symmetrical problems (thick cylinders, rotating discs). Theory of plates and shells. Thermal stress analysis. Energy methods. Experimental stress analysis methods.

D. McCammond

MEC 261F DIFFERENTIAL EQUATIONS

II – 3 3 – 3 10

First-order equations. Second-order equations. Operator techniques. Systems of equations. Power series for variable-coefficient equations. Numerical techniques.

A. W. Neumann

MEC 302S DYNAMICS II

III – 3, IV – 3 (elective) 3 – 1½ 10

Brief review of basic laws of classical Newtonian mechanics. Euler angles and gyrodynamics. Generalized co-ordinates and their transformation. Theorem of virtual work and d'Alembert's principle. Kinetic and potential energy. Dissipative power functions and Lagrange equations of motion. Determination of constraint forces. Variational dynamics. Hamilton's equations and principle. Astronautics. Orbital mechanics. Rocket mechanics.

R. C. Flanagan

MEC 303S VIBRATIONS

III – 3 3 1 2 10

Analysis of single degree of freedom systems. Various types of damping forces. Vibration isolation. Vibration measuring instruments. Steady state and transient vibrations. Vibration of multi-degree of freedom systems. Numerical methods of frequency analysis. Lagrange equations and Hamilton's principle. Energy methods. Vibration of strings, beams and plates. Torsion of shafts. Approximate methods. Introduction to non-linear vibrations. Introduction to wave propagation in solids.

D. L. Allen

MEC 313S ELASTICITY

III – 3, IV – 3 (elective) 3 – 1½ 10

Review of stress and strain tensors and generalization of Hooke's law. Equations of equilibrium and compatibility. Solution procedure using displacements and stress functions. Illustration of the theory by application to beams, rotating discs, thick composite cylinders, torsion of non-circular sections, stress concentration and thermal stresses. Introduction to finite difference and finite element methods of solution.

B. Tabarrok

MEC 315S EXPERIMENTAL STRESS ANALYSIS

III – 5nt, 5p (elective) 2 1 1 8

The elementary concepts of the theory of elasticity will be given. The experimental techniques of measuring stress or strain will be studied; these techniques include strain-gauge, photoelastic, brittle-coating and moire methods. Experimental work will be included.

G. E. Godfrey

MEC 321F THERMODYNAMICS

III – 3 3 1 2 10

Review of energy and matter concepts; first law of thermodynamics illustrated by closed and open system applications; the state postulate; Characteristics of pure substances; the ideal gas; statistical basis of entropy and the second law of thermodynamics; fluxes and production of entropy; application of second law to engineering systems, processes and ideal cycles; flow and non-flow availability analysis; mixtures of non-reacting substances. Textbook: *Engineering Thermodynamics* – Reynolds and Perkins.

D. S. Scott

MEC 322S THERMAL ENERGY CONVERSION

III – 3 3 3 – 10

The application of thermodynamics to heat engines, refrigerators and processes associated with useful energy transformations. Engine and turbine cycles for vapours and gases. Combustion processes. Psychrometry and air-conditioning. Direct energy conversion devices.

F. C. Hooper

MEC 323S COMBUSTION THEORY

III – 3, IV – 3 (elective) 3 – 1½ 10

Fundamentals of combustion. Physical and thermo-chemical relationships of combustion. Mechanisms of burning. Ignition. Stabilization of flames. Limits of flammability. Laminar and turbulent flames. Diffusion flames. Practical combustion systems for gaseous, liquid and solid fuels.

A. B. Allan

MEC 327F HEAT ENGINEERING

III – 5nt 2 3 – 8

This course consists of a study of the fundamental concepts of macroscopic thermodynamics, and their applications to closed and open dynamic systems. An examination of the principal power cycles is undertaken in relation to the properties of the working media involved. Emphasis is placed on a thorough understanding of the three basic laws of thermodynamics. Textbook: *Concepts of Thermodynamics* – Obert. Reference Books: *Engineering Thermodynamics* – Hall and Ibele. *Thermodynamics* – Van Wylen.

F. C. Hooper

MEC 341F FLUID MECHANICS I

III – 3 3 2 1 10

Introductory concepts. Fluid properties. Systems of stresses. Hydrostatics. Kinematics and dynamics of flow. Viscous laminar flow. Boundary layer theory. Turbulent flow. Internal and exterior flows.

J. F. Keffer

MEC 342S FLUID MECHANICS II

III – 3, IV – 3 (elective) 3 – 1½ 10

Kinematics of fluid motion: equation of continuity, stream functions, circulation and vorticity. Dynamics of ideal fluid flow: fundamental equations, fluids at rest, filament flow, potential flow. Dynamics of real fluid flow: fundamental equations, similitude, exact solutions, creeping flow, boundary layers. Turbulent flow: general features, wall turbulence, free turbulence. Diffusion processes: molecular diffusion, diffusion and convection in turbulent flow, dispersion in one-dimensional flow. Tutorials, films and selected experiments complementing lecture material.

H. J. Leutheusser

MEC 349S TRANSPORT PHENOMENA

III – 8, III – 4 (elective) 3 1½ 1½ 8

A study of the forces and motion produced by various fluid properties. Gravitational, viscous and inertial forces are considered in detail. Momentum, energy and continuity relation, boundary-layer approximation, turbulence, flow in pipes and around submerged bodies. Steady-state conduction in one dimension; extended surfaces; heat conduction with two or more independent variables; forced convection and dimensional analysis; heat transfer by free convection; radiant heat transfer; heat transfer by combined conduction and convection; heat transfer in liquid metals.

J. F. Keffer

MEC 351F FLUID MECHANICS

III – 1; III – 2C 3 3 – 10

Introduction: fluid and flow characteristics, dimensions and units. Fluid statics: fundamental equation, gravity and inertia action, engineering applications. Fundametals of one-dmensional flow: conservation principles of mass, energy and momentum, applications to ideal-fluid flow. Dimensional analysis and similitude. Fundamental concepts of real fluid flow: laminar and turbulent flow, boundary layer concept, flow about immersed objects. Flow in closed conduits: flow development, friction loss, minor loss, typical pipe-flow problems. Flow in open channels: uniform flow, varied flow. Special topics of interest to civil engineers. Tutorials, films and experiments complementing lecture material.

H. J. Leutheusser

MEC 354F FLUID MECHANICS

III – 5nt 3 3 – 8

A fundamental approach to the mechanics of fluid motion. Continuum concepts. Kinematics and dynamics of flow. Irrotational motion. Vorticity. Laminar flow solutions. Turbulent motions. Applications to conduit flow. Free surface waves. Fluid machinery.

J. F. Keffer

MEC 357S CONTROL ENGINEERING

III – 4 2 1 1 8

Introduction to the dynamic behaviour of linear systems. The feedback principle. Stability and response of linear control systems. The convolution theorem. Transfer functions of linear systems. Analysis and design of linear control systems. Introduction to servomechanism technology for control system design. Problems and laboratory experiments will accompany the lectures. (Prerequisite MAT 294S)

D. B. Cherchas

55—MEC 362F ENGINEERING ANALYSIS I

III – 3 3 – 3 10

Analytical techniques include Laplace transforms, series solutions of ordinary differential equations, special functions, vector calculus.

D. F. James

MEC 363S ENGINEERING ANALYSIS II

III – 3 3 – 3 10

Continuation of Engineering Analysis I. Topics include boundary value problems and eigenfunction expansions, higher-dimensional calculus, introduction to partial differential equations, functions of a complex variable.

C. A. Ward

MEC 371F ANALYSIS AND DESIGN OF MECHANISMS

III – 3 3 – 3 10

Analytical, graphical and computer techniques for kinematic analysis of mechanisms. Synthesis of linkages. Cams, gears and mechanism trains. Dynamic analysis including forces, balancing and control of speed fluctuation.

I. W. Smith

MEC 420F THERMAL ENVIRONMENTAL DESIGN

IV – 3 (elective) 3 1½ – 10

Psychrometrics, heating and cooling. Refrigeration including vapor compression, absorption and thermolectric. Solar radiation. Design and applications to the control of environmental systems in residential, public and industrial buildings and processes. Computer-aided design procedures.

A. H. Abdelsmessih

MEC 424F THERMAL POWER GENERATION

IV – 3 (elective) 3 1½ – 10

Plants and processes in major power production. Overall design and heat balance in steam plants. Non-central power production. Characteristics of portable power units and auxiliaries.

A. B. Allan

MEC 425F/S MICROSCOPIC THERMODYNAMICS

III – 5nt; III – 3, (elective) 3 1½ – 10

The molecular approach to the description of thermodynamic systems. Ergodic hypothesis, ensemble averages, temperature and entropy. Fluctuations about the equilibrium states and rate processes.

C. A. Ward

MEC 428F THERMAL ENERGY CONVERSION

IV – 5nt 3 3 – 11

The thermodynamics and gas dynamics of thermal energy conversion. Steam power cycles, fossil fuel energy sources, magneto-hydrodynamics, power generation, combustion, new trends and research developments.

A. B. Allan

MEC 431F/S HEAT AND MASS TRANSFER

IV – 3 3 1½ 1½ 9

Steady state and transient conduction, surface and gas radiation, convection, boiling, condensation and combined mechanisms of energy trasport are considered, together with an introduction to mass transport. Application of these topics in the design of heat transfer equipment.

F. C. Hooper, A. H. Abdelmessih

MEC 433S HEAT TRANSFER

IV – 5nt 2 – – 7

Steady state and transient conduction, surface and gas radiation, convection, boiling, condensation and combined mechanisms. Special attention is given to analogue and computational procedures and to consideration of the manner in which novel or complex problems may be approached.

F. C. Hooper

MEC 443S APPLIED FLUID MECHANICS

IV – 3 3 3 – 9

Study of one-dimensional gas dynamics encountered in Engineering practice including nozzle flows, friction, heating and normal shock waves. Water hammer and design procedures for alleviation, hydraulic transients in pipe system. Design principles and operational characteristics of flow machines, primarily turbo-machines. Lift and drag on submerged bodies and application to flow-induced vibrations. Dispersion of air pollution and concepts of pollution control.

W. D. Baines

MEC 452S HYDRAULIC ENGINEERING

IV – 1, 2C (elective) 3 2 – 8

Review of flow principles. Techniques of field measurement. Open channel and closed-circuit flow. Hydraulic structures and appurtenances, transitions, controls; dams; navigation works; methods of construction. Hydraulic machinery, pumps, turbines, power and control systems. Design and testing of hydraulic engineering systems; analytical procedures, numerical methods and computer simulation. Systems analysis.

G. D. Ransford

MEC 455F/S CONTROL SYSTEMS I

IV – 3 3 1½ 1½ 10

Analysis and synthesis of linear feedback systems by frequency response methods and the rootlocus technique. Introductions to nonlinear control system, the statespace technique, and digital computer control.

J. Vande Vegte

MEC 456S CONTROL SYSTEMS II

IV – 3 (elective) 3 – 1½ 10

The analysis of physical systems by state-space techniques. Controllability and observability of multivariable feedback systems. Design of multivariable feedback systems by the techniques of optimal control and of pole assignment. Introduction to Fluid Power Control and Fluidics. (Prerequisite MEC 455F)

J. Vande Vegte

MEC 472S DESIGN

IV – 3 2 – 6 10

This course is intended to utilize all of the students' knowledge and training in Mechanical Engineering and to apply this knowledge to design. The lectures will cover design practice, criteria and methodology. The projects will be broad in nature and will be supervised by staff members who will pose projects on which students will work in small groups.

Staff

MEC 473F COMPUTER-AIDED DESIGN

IV – 3 (elective) 3 – 1½ 10

Value theory, decision theory. Modelling, numerical methods, problem oriented computer languages. Analytical optimization methods. Numerical optimization: linear, boundary and multi-dimensional search techniques; linear and dynamic programming. Reliability. Design simulation techniques. Computer graphics.

R. G. Fenton

MEC 475S MANUFACTURING ANALYSIS

III – 3, IV – 3 (elective) 3 – 1½ 10

Introduction to plasticity. Mechanics of metal forming and machine processes. Tool wear. Machine tool vibration. Surface finish. Thermal effects in machining and forming. Economy of machining. Modern machining processes. Numerical and adaptive control of machines.

R. G. Fenton

MEC 499 THESIS OR DESIGN PROJECT

IV – 3 – – – 11, – – – 3

The thesis may consist of one of the following:

1. Group design projects:
   Large projects covering a broad range of mechanical engineering will be offered. The projects will refer to realistic situations and contribute to the solution of the design problem, i.e. individuals will specialize in the various aspects of the design.
2. Individual research and design projects:
   With the approval of the thesis co-ordinator and a supervising professor, a student may perform original research, experimentation, or specialized design.
3. Interdisciplinary group design:
   The interdisciplinary group design course APS 401 may be taken in lieu of MEC 499.

Full details of the thesis-project requirements are available on request from the Departmental office.

Staff

DEPARTMENT OF METALLURGY AND MATERIALS SCIENCE

MMS 100S STRUCTURE AND PROPERTIES OF MATTER

I – 1, 2, 3, 4, 5, 6, 7, 8 (elective) 3 1½ – 8

An introduction to the structure and properties of the different states of matter in terms of the interatomic potential and thermal energy. A comparison of solids, liquids and gases, with special attention being directed towards crystalline solids, in order to establish a theoretical framework to account for the properties of engineering materials. Specific topics considered include elasticity, viscosity, surface properties and capillarity, wave motion and the thermal and optical properties of matter.

Staff in Metallurgy and Materials Science and Physics

MMS 201F STRUCTURE OF MATERIALS AND METALLOGRAPHY

II – 8 2 3 1 8

A course dealing with both the theoretical interpretation and the experimental determination of the structure of solids. Structure is discussed in terms of crystallography, defects in crystals, amorphous materials, polycrystalline grain structure and phase distribution in alloys. Metallographic techniques for the determination of microstructure by optical, x-ray, electron and field-ion microscopy are considered, as are quantitative metallography and the introductory principles of x-ray diffraction.

W. A. Miller

MMS 202F PHYSICAL CHEMISTRY I

II – 8 21 2 8

The physical-chemical properties of matter: ideal and real gases, liquids and solids, surface properties, viscous flow, and the concept of energy. Heat capacities and Debye's cubic law. Entropy and free energy for pure materials, order-disorder phenomena and configurational entropy. Introduction to solution properties and chemical equilibria. Ellingham diagrams and experimental methods. (Prerequisite MAT 180F)

S. N. Flengas

MMS 203S PHYSICAL CHEMISTRY II

II – 2B, 8 2 – 3 8

Phase diagram calculations – van't Hoff equations for the liquidus. Solid solubility under equilibrium conditions. Binary and ternary systems. Structure of liquids. Metallurgical systems such as the Fe-O, Fe-C and Fe-O-Sil, are discussed in detail. Solubility of gases in liquid metals. (Prerequisites MMS 202F or MMS 225F)

J. M. Toguri

MMS 204S METALLURGICAL CHEMISTRY

I – 8 2 3 2 9

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber cycle and replacement reactions. Point defects, non-stoichiometry and conductivity. The Schroedinger equation and its solution in terms of orbitals. Bonding in condensed phases. The laboratory deals with the instrumental analysis of ores, concentrates, slags and alloys.

C. B. Alcock, R. T. McAndrew, H. U. Ross

MMS 205S MATERIALS SCIENCE

II – 8 4 – – 7

A course on the structure and properties of plastics, glass and ceramics.

Staff in Materials Science

MMS 221F MATERIALS SCIENCE I

II – 7 3 1½ – 8

Part I deals with the structure of materials in terms of atomic bonding, crystal structure, defect structure and microstructure. Various processes that influence structure and properties of materials are discussed, such as diffusion, phase transformations, plastic deformation, fracture and the decomposition of super-saturated solid solutions. Other topics covered include the purification of semiconductor materials and the growth of single crystals, a discussion of selected useful metallic and ceramic materials, and a brief outline of their fabrication techniques.

Part II deals with the macroscopic response of materials to mechanical loading with special reference to deformability, stability and strength of structural elements which are subjected to axial and biaxial stresses, flexure and torsion.

J. W. Rutter, R. H. Mills

MMS 222F MATERIALS SCIENCE

II – 4, III – 2B (elective) 3 3 – 8

The effects of microscopic and atomic structures on the electrical, chemical and mechanical properties of engineering materials. The topics covered include atomic bonding, structures of ideal and real crystals, phase transformations and diffusion, chemical and mechanical properties, and oxidation and corrosion phenomena. The laboratory experiments will include x-ray studies of crystal structure; measurement of resistivity and magnetism of solids; studies of alloy phases and transformations; dislocation patterns, stress-strain relationships, stress-relaxation and fatigue phenomena; oxidation and corrosion reactions.

B. Ramaswami

MMS 223S MATERIALS SCIENCE

II – 3 3 1½ – 8

The effects of microscopic and atomic structures on the properties of engineering materials. The topics covered include atomic bonding and structures of materials, diffusion, crystal growth and solidification, plastic deformation and annealing, precipitation hardening, phase transformations especially in ferrous materials, relationships between structures and mechanical properties of metallic and non-metallic materials, and composite materials. The laboratory experiments are designed to illustrate the principles underlying the relationship between structures and properties of engineering materials.

K. T. Aust

MMS 224S INTRODUCTORY METALLURGY

III – 2A, 2C, IV – 2A (elective) 2 – – 6

An introduction to the metallurgical processes used to extract metals from their ores and to refine and fabricate the final material into useful products. The course is designed around the flowsheets of processes for many of the most important metals.

H. U. Ross

MMS 225F PHYSICS AND CHEMISTRY OF MATERIALS

II – 2B 4 – 3 9

A course dealing with the structure of solids, liquids and gases. The physio-chemical properties of matter are considered from a thermodynamic viewpoint. (Prerequisite MAT 180F)

S. N. Flengas, W. A. Miller

MMS 226S INORGANIC CHEMISTRY

II – 2B 2 – 2 8

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber-cycle and replacement reactions. Point defects, non-stoichiometry and conductivity. The Schroedinger equation and its solution in terms of orbitals.

C. B. Alcock

MMS 227S MATERIALS SCIENCE II

II – 7 2 1½ – 7

The magnetic, dielectric and conductive properties of materials, as related to their structure. Magnetic properties: dia-, para-, ferro-, antiferro-, and ferri-magnetic phenomena; magnetic domains and domain wall motion; "hard" and "soft" magnetic materials, magneto-striction. Dielectric materials; insulating properties, conduction mechanism, dielectric loss. Ferro-electric materials. Electrical conduction; temperature, dependence, effect of composition and structure on conductivity. Thermoelectric phenomena. (Prerequisite MMS 221F)

U. M. Franklin

MMS 301F MINERAL PROCESSING I

III – 8, 2B 2 3 1 8

The theory and practice of minerals beneficiation including particle size measurement, comminution, sizing, liquid-solid separation and ore concentration. The course also includes the relevant aspects of mineralogy, surface chemistry and the movement of solid particles in liquid media.

H. U. Ross

MMS 302F THERMODYNAMICS

III – 8 2 – 4 8

A study of chemical equilibria at high temperatures in extractive metallurgy – slag-metal reactions – classical theory of solutions – phase transformations – thermodynamic relationships in phase diagrams. (Prerequisites MMS 203S, MAT 293F)

S. N. Flengas

MMS 303F PHYSICAL METALLURGY

III – 5m, 8 3 3 – 8

An introduction to the fundamental basis of microstructure control stressing the importance of alloying, plastic deformation and annealing. The principles of solification, crystal growth, and phase transformations in solids, with particular reference to steels, are considered in detail.

U. M. Franklin, G. B. Craig, J. W. Rutter

MMS 304S PHYSICS OF METALS

III – 5m, 8 3 3 – 8

Plastic deformation and mechanical properties are discussed in terms of dislocation theory. The annealing processes of recovery, recrystallization and grain growth and the structure and properties of interfaces in materials are also considered. (Prerequisite MMS 303F)

K. T. Aust, W. A. Miller, B. Ramaswami

MMS 305S EXTRACTIVE METALLURGY I

III – 2B, 8 4 3 – 9

A fundamental treatment of the pyrometallurgical processes involved in the production of the important metals, including oxidation of sulphides in the liquid and solid states, reduction of oxides and chlorides, matte-slag and metal-slag equilibria and kinetics and the distillation of metals. Experiments in materials processing, including roasting, smelting, leaching, refining, electrolysis. (Prerequisite MMS 302F)

C. B. Alcock, A. McLean, H. U. Ross, J. M. Toguri

MMS 306F METALLURGICAL THERMODYNAMICS

III – 5m 3 – 4 9

A study of chemical equilibria at high temperatures in metallurgy; slag-metal reactions; chemical theory of solutions; alloys; phase transformations; thermodynamic relationships in phase diagrams; statistical concept of entropy; simple partition functions;

quasichemical approach to the theory of solutions; methods of investigating thermodynamic properties.

S. N. Flengas, A. McLean

MMS 307S MATERIALS SCIENCE

III – 5m 3 – – 8

The course deals with the relationship between the structure and properties of non-metallic solids. Topics to be discussed are: thermodynamics and kinetics of phase transitions, phase diagrams, diffusion, crystal defects, and the effect of structure on physical, chemical and mechanical properties. (Prerequisite MMS 303F)

B. Ramaswami, G. C. Weatherly

MMS 331F MATERIALS SCIENCE LABORATORY

III – 8 (elective) – 3 1 7

Projects in materials science, chosen by the student, and carried out in close consultation with a staff supervisor. (Corequisite MMS 303F)

Staff in Metallurgy and Materials Science

MMS 332S EXTRACTIVE METALLURGY LABORATORY

III – 8 (elective) – 3 1 7

A laboratory project in extractive metallurgy relating to course 305. (Corequisite MMS 305S)

Staff in Metallurgy and Materials Science

MMS 401F EXTRACTIVE METALLURGY II

IV – 8 3 3 1 9

Oxidation reactions, acid and basic steelmaking; transport considerations with reference to open hearth, converter, B.O.F. and electric furnace steelmaking; continuous steelmaking processes, the influence of vacuum treatment and argon rinsing in steelmaking. The extraction and refining of metals by hydrometallurgical techniques in terms of thermodynamic and kinetic principles. (Prerequisite MMS 305S)

A. McLean, H. U. Ross, J. M. Toguri

MMS 402F SOLID STATE SCIENCE

IV – 5m, 8 3 3 1 9

The course deals with relationships between crystal structure and the electronic and magnetic properties of solids, as well as the formation and stability of alloy phases and intermetallic compounds. The laboratory will be devoted mainly to x-ray and electron techniques applicable to both single crystals and polycrystalline materials. (Prerequisite MMS 304S)

U. M. Franklin, G. C. Weatherly

MMS 404S ELECTROCHEMICAL PROCESSES

IV – 8, 2B (elective) 2 – 2 7

Electrochemistry of solids, liquids, and of high temperature systems. Corrosion. Fused salt electrochemical cells. Thermodynamics of imperfections and properties of ionic solids. (Prerequisite MMS 302F)

S. N. Flengas

MMS 406S ADVANCED CHEMICAL METALLURGY

IV – 8 (elective) 1 – 3 7

Selected topics related to the behaviour of metallic, ceramic and metal-slag systems at high temperatures. Thermodynamic and transport properties of alloys and metallic oxides, carbides, silicides, etc. High temperature corrosion reactions and vaporization processes. (Prerequisites MMS 302F, MMS 401F)

Staff in Metallurgy and Materials Science

MMS 407S METALLURGICAL SYSTEMS ANALYSIS

IV – 8 (elective); IV – 2B 2 – 1 7

The methods for evaluating metallurgical processes in terms of material resources and cost are considered together with the scientific factors which determine the choice of processes in order to obtain a synthesis of operational decision making. (Prerequisite MMS 401F)

Staff in Metallurgy and Materials Science

MMS 408S MATERIALS ENGINEERING

IV – 8 (elective) 3 – – 7

A course on the processing and selection of engineering materials. Processing techniques such as casting, metal working, welding, heat treatment, sintering and vapour deposition are considered. Factors governing materials selection are discussed in general and in relation to such specific applications as high and low temperature service, corrosion-resistant materials, nuclear materials, electronic materials, etc. (Prerequisite: any materials science course)

Staff in Metallurgy and Materials Science

MMS 409S HIGH TEMPERATURE PHYSICAL CHEMISTRY

IV – 5m 2 – 2 8

Properties of solids and liquids at high temperatures; thermodynamics of defects; solid oxide electrolytes; mechanism of electrical conductivity in ceramic phases; fused-salt electrolytes; reactions in fused-salt media; electrochemical cells at high temperatures; fuel cells; structural properties of simple and complex liquid phases; electrochemical corrosion and passivation; kinetics of heterogeneous reactions. (Prerequisite MMS 306F)

S. N. Flengas

MMS 410F THEORY OF METALLURGICAL REACTIONS

IV – 5m 2 – 2 8

Metal extraction and refining processes are examined in terms of chemical thermodynamics and kinetics. The principles and methods of extraction of ferrous and nonferrous metals, roasting, leaching and electro-winning are typical of the subjects discussed. (Prerequisite MMS 306F)

J. M. Toguri

MMS 411S ADVANCED MATERIALS SCIENCE

IV – 5m; 8 (elective) 3 3 – 8

This course is offered to those students whose primary interest lies in the research aspects of materials. Recent developments in materials science are discussed in fields such as crystal growth, purification of materials, high-vacuum studies, preparation and characterization of clean surfaces, interfacial structures and properties, Auger emission and impurity segregation, environmental interactions. The laboratory work consists of research projects on contemporary problems in the field of materials science. (Prerequisite MMS 402F))

K. T. Aust, J. W. Rutter

MMS 412S MINERAL PROCESSING II

IV – 8 (elective); III – 2B 2 1½ – 7

This is a continuation of course 301F. Topics considered include particle size analysis and characterization; the motion of solids in fluids under laminar, transitional and turbulent conditions and the application of surface chemistry to minerals and flotation. (Prerequisite MMS 301F)

H. U. Ross

MMS 413F HYDROMETALLURGY

IV – 2B; IV – 8 (elective) 2 1½ 1 8

Theory and practice of metal production from ores and concentrates by chemical reaction in aqueous solution. Thermodynamic and kinetic fundamentals are emphasized. Topics covered include leaching, solution purification, metal precipitation, electrowinning and electrolytic refining. Examples of integrated process flowsheets are studied and compared to alternative phyrometallurgical processes.

R. T. McAndrew

MMS 414F MINERAL ENGINEERING

IV – 2B 2 1½ 1 8

This course deals with the design, operation and control of mineral processes. Operations studied include comminution, concentration, dewatering, roasting, agglomeration, balling, sintering, sampling, materials handling and process instrumentation.

H. U. Ross

MMS 415S PHYSICS AND CHEMISTRY OF SURFACES

IV – 2B 2 – 1 8

Structure of inorganic surfaces, surface area measurement and the determination of surface free energies. Adsorption isotherms and the kinetics of surface reactions. Surface migration and desorption from surfaces. The structure of surface layers and of bounding surfaces between solids.

Staff in Metallurgy and Materials Science

MMS 416S NUCLEAR MATERIALS

IV – 8 (elective) 3 – 1 7

An introduction to structure-property relationships in nuclear materials such as uranium, thorium, zirconium, stainless steel, etc. Topics to be discussed include properties of liquid metals and corrosion in liquid environments; creep, thermal cycling and thermal fatigue; radiation damage; nonstoichiometry in inorganic compounds; production and fabrication techniques of fuel rods and cladding materials. (Prerequisite: any materials science course)

Staff in Metallurgy and Materials Science

MMS 431F POWDER METALLURGY

IV – 8 (elective) 2 – 2 8

Production and agglomeration of powders, the theory and practice of sintering, and the application of powder methods to the production of refractory metals, cemented carbides and other materials. (Prerequisite: any materials science course)

K. T. Aust, J. W. Rutter

MMS 499 THESIS

IV – 8, 2B – 6 – 6, – 12 – 12

The student chooses an experimental problem involving original work, which normally is related closely to the current research of a staff member. The student is asked to prepare both a written report and an oral presentation describing the work. No laboratory time is specified for the engineering science (materials science option) thesis (APS 495) but the project is of essentially the same extent as that described above.

Staff in Metallurgy and Materials Science

DEPARTMENT OF PHYSICS

PHY 180F ELEMENTS OF PHYSICS I (MECHANICS)

I – 5 2 1½ 1 9

Introduction to atomic and nuclear physics. Addition and multiplication of vectors with physical applications. Trajectories of particles. Rotational motion, conservation of angular momentum, moments of inertia, gyroscopes. Non-uniform accelerations, simple harmonic motion. Reaction kinematics. Philosophy of conservation laws and symmetries. Gravitational and other natural forces.

K. G. McNeill

PHY 181S ELEMENTS OF PHYSICS II (THERMODYNAMICS AND STATISTICAL PHYSICS)

I – 5 2 1½ 1 9

Heat and thermodynamics, the laws of thermodynamics with physical applications. Ideal gases, kinetic theory, Maxwell-Boltzmann distribution of molecular velocities, specific heats of monatomic and polyatomic gases. Basic probability notions, postulates of statistical physics, entropy, absolute temperature, the canonical distribution. Crystalline symmetry, elastic behaviour of solids. Dynamics of crystalline lattices, specific heats and solids, heat conductivity, thermal expansion.

D. G. Ivey

PHY 215F GEOPHYSICS

II 4, 6, III – 2a, 2c (elective) 2 – 1 8

A course in the physics of the earth, atmosphere and magnetosphere, offered to students in science. The principal conclusions reached by geophysicists about the planet, its evolution, and the processes taking place on it are introduced, as well as an outline of the methods utilized in attacking current research problems. Reference: Flohn – *Weather and Climate*; Gass, Smith and Wilson – *Understanding the Earth*.

R. List, G. Garland

PHY 218 APPLICATIONS OF PHYSICS IN MEDICINE

II – 4, 6 (elective) 2 – 1 8

This course covers particular parts of physics which are often applied in medical practice and research and intimately mixes the pure with the applied physics. Topics include: radioactivity and tracer techniques, neutron activation analysis, optics and the resolution of instruments, x-rays and holography, electricity and instruments used in medicine, mechanics of the body, hydrodynamics of the circulating system.

K. G. McNeill

PHY 244S ELASTICITY AND FLUID MECHANICS

III – 5g 2 – – 8

A mathematical course in classical physics particularly for those interested in geophysics and meteorology. The elasticity part includes the definition and use of cartesian tensors to describe infinitesimal strains, stresses, and their relations. Fluid mechanics include fluid statics, continuity, Bernoulli, Euler, and Navier-Stokes equations, potential flow, vortex flow. Textbook: R. R. Long – *Mechanics of Solids and Fluids*; D. R. F. Harleman – *Fluid Dynamics*.

J. V. Iribarne

PHY 280F ELEMENTS OF PHYSICS III (FIELDS AND WAVES)

II – 5 3 1½ 1 8

Principle of relativity, Lorentz transformation, Einstein's special relativity, relativistic dynamics, space-time geometry, the electromagnetic field, analysis of a vector field. Matter in electrostatic and magnetostatic fields, electromagnetic field of uniformly moving charges, Maxwell's equations, radiation and its detection. Interference of electromagnetic waves, Huygen's principle and diffraction. Maxwell's equations in the presence of matter.

D. G. Ivey

PHY 281S ELEMENTS OF PHYSICS IV (QUANTUM PHYSICS)

II – 5 2 1½ 1 8

Classical systems and quantum systems. Wave-particle duality, Heisenberg uncertainty principle, electron and nuclear spin. Schroedinger equation. Eigenvalues and eigenfunctions. Transition probabilities. The harmonic oscillator. The hydrogen atom. Quantum aspect of electromagnetic radiation, quantum electrodynamics. Nuclear interactions, stable and unstable nuclei. Elementary particles – their production and interactions.

T. Drake

PHY 282F INTRODUCTION TO MODERN PHYSICS

II – 2B, 8 3 – 7

The principals of modern physics with emphasis on applications to engineering. Specific topics include: the interaction of electromagnetic radiation with matter; crystal structure from diffraction (x-rays, etc.); the nuclear reactor; radioactivity and the ages of minerals, ocean sediments, artifacts; the laser and the maser; superconductors and superfluids. Reference: Oldenberg and Rasmussen – *Modern Physics for Engineers.*

T. Drake

PHY 282S INTRODUCTION TO MODERN PHYSICS

II – 1, 2C 3 – 7

Description the same as for PHY 282F.

N. Edwards

PHY 283F BASIC CLASSICAL AND MODERN PHYSICS

II – 2A 3 – – 8

A review of dynamics emphasizing the energy-momentum point of view and conservative systems; Rotational dynamics, planetary motion, motion in noninertial frames; oscillatory and wave motion; thermal physics including free energies and entropy; an introduction to quantum phenomena, radioactivity; basic explanations for the thermal, deformational and electrical properties of materials.

R. Desai

PHY 284S BASIC ELECROMAGNETISM

II – 2 1 3 – 7

The weekly lecture discusses alternating current circuits and topics related to the laboratory experiments. The laboratory deals with AC circuits, and the measurement of phenomena such as radioactive decay, x-ray diffraction and the earth's magnetic and gravitational field. This course follows PHY 283F.

G. J. Luste

PHY 327F MODERN PHYSICS LABORATORY

III – 5p – 6 – 10

Experiments of both a pure and applied nature are available in the areas of atomic, molecular, solid state, nuclear and particle physics. The experiments are open-ended; the student may spend more or less time on any particular experiment depending on his particular interest. The laboratory is open five days a week. Demonstrators will be in the laboratory at the times shown in the time-table and available for consultation at other times. Registration at the Physics office first week of term. (Prerequisite: PHY 180F, 181S, 280F, 281S)

PHY 332F MOLECULAR BIOPHYSICS

III – 5p (elective) 2 – – 8

The physical and chemical properties of some biologically important macromolecules in relation to their functions. Techniques such as sedimentation, chromatography, spectroscopy, scattering of photons and electrons. The course is designed to give students with a physics and chemistry background an insight into the application of the exact sciences to the solution of biological problems. (Prerequisite: PHY 180F, 181S, 280F, 281S)

PHY 333S CELLULAR BIOPHYSICS

III – 5p (elective) 2 – – 8

The emphasis will be on the application of principles from physics, chemistry and genetics to quantitative studies in cell biology. Selected areas in biophysics such as cellular differentiation, the regulation of macromolecular biosynthesis, and the application of biophysical methods to problems in medicine, will be discussed in detail. (Prerequisite: PHY 180F, 181S, 280F, 281S)

PHY 334F INTRODUCTION TO SOLID STATE PHYSICS

III – 5m, nt, p, III – 8 (elective) 2 – – 8

Introduction to the basic features of solid state physics including: crystal lattices, their structure and description; propagation of waves in periodic structures, including x-rays and neutron diffraction; properties of phonons and the behaviour of electrons in crystalline solids; the principal properties of metals, semi-conductors and insulators; some features of the magnetic behaviour of metals. (Prerequisite: PHY 180F, 181S, 280F, 281S))

PHY 335F INTRODUCTION TO NUCLEAR PHYSICS

III – 5nt, p 2 – – 8

Important discoveries in nuclear and particle physics. Properties of the nucleus and of nuclei. The measurement of atomic masses; nuclear binding energies, binding energy and mass formulas, liquid drop model and fission. Introduction to nuclear shell and collective models. Interaction of charged particles and uncharged particles with matter; particle detection, energy and momentum measurements. Radioactive decay phenomena: theory and experiment. Nuclear reactions and cross sections. Particle accelerators. (Prerequisite: PHY 180F, 181S, 280F, 281S)

PHY 336S APPLIED NUCLEAR PHYSICS

III – 5nt, p (elective) 2 1 – 8

Fission and fusion. Tracer techniques. Biological effects of radiation. Applications of nuclear techniques in various fields. Neutron and scintillation radiography. Activation analysis. Those taking PHY 325/326Y/328S concurrently meet the laboratory requirement. This course makes use oft he material contained in PHY 335F. (Prerequisite: PHY 180F, 181S, 280F, 281S)

PHY 337S ELEMENTARY PARTICLE PHYSICS

III – 5p 2 – – 8

A contemporary picture of the world of elementary particle physics. Introduction to the classification of particle states, types of interactions, experimental methods, conservation laws and invariance principles. Discussions to include weak, electromagnetic and strong interactions and to point out the unsolved problems that are currently being investigated. (Prerequisite: PHY 180F, 181S, 280F, 281S)

PHY 338X EXPLORATION GEOPHYSICS

IV – 2 2 3 – 8, 2 3 – 8

An introduction to the physical principles underlying the important methods of geophysical prospecting. Particular attention is given to seismic, gravitational, magnetic and electromagnetic methods. Textbook: *Introduction to Geophysical Prospecting* – Dobrin.

G. F. West

PHY 353S THERMODYNAMICS

III – 5p 2 – – 8

The general principles of classical thermodynamics are discussed and related to statistical physics. Representative applications in fluids, solids, magnetic systems and phase transitions are considered. (Prerequisite: PHY 180F, 181S, 280F, 281S)

PHY 382S QUANTUM AND STATISTICAL MECHANICS

III – 5p, 5nt; 5e, 5g (elective) 3 – – 8

Time independent and time dependent perturbation theory. Transition probabilities. Multielectron atoms. Classical Maxwell-Boltzmann statistics. Bose-Einstein and Fermi-Dirac Statistics. Statistical thermodynamics. This course builds on the material contained in PHY 181S and PHY 281S. (Prerequisite: PHY 180F, 181S, 280F, 281S)

PHY 384F THERMODYNAMICS AND STATISTICAL MECHANICS

III – 7 3 – 1 7

The behaviour of physical systems is discussed, mainly from the statistical point of view, but also by using classical thermodynamics. Molecular and quantum physical concepts are stressed. The general approach is of a fundamental physical nature but examples and applications will be of interest to electrical engineers.

PHY 422F TIME SERIES ANALYSIS LABORATORY

IV – 5g – 6 – 8

A laboratory concerned with mathematical and computational techniques for the analysis of discrete data series. Topics include Fourier, z and Laplace transforms in continuous and discrete representations, aliasing effects of sampling continuous functions, convolution and correlation, bandpass and optimum least squares, filtering and estimation of power spectra. The course is particularly relevant to geophysical data analysis. Text. Hsu, *Fourier Analysis.* (Prerequisite: Open only to IV-5g)

PHY 427F QUANTUM PHYSICS LABORATORY I

IV – 5p – 6 – 8

This laboratory is basically a continuation of PHY 327. Experiments similar to those of PHY 327 are available but at a more advanced level. In addition several experiments of a research nature may be undertaken outside the laboratory. The laboratory is open five days a week. Demonstrators will be available in the lab at times shown in the timetable and available for consultation at other times. Registration at the Physics office first week of term. (Prerequisite: PHY 382S)

PHY 428S QUANTUM PHYSICS LABORATORY II

IV – 5p – 6 – 8

This laboratory course is provided to allow the student to conduct experiments of a research nature under the direct supervision of a member of the Physics staff. In some cases, with the permission of the Chairman of Engineering Science, this project may be combined with the thesis APS 498S. A student wishing to enrol in this course is expected to seek out a supervisor of his choice and to choose a problem that is acceptable both to himself and to the staff member. A list of available staff and possible projects may be obtained from the Physics office. (Prerequisite: PHY 382S)

PHY 442 PHYSICS OF THE EARTH

III – 5g 2 – – 7, 2 – – 7

A course providing a physical background for the study of the interior of the earth and the moon, and the department of their surface features. Topics include seismic waves and the earth's structure, the gravitational field and the earth's mass distribution, geomagnetism, geochronology, and the mechanical and thermal properties of the earth's interior. Recent results from the Apollo Missions will be discussed. Text: Garland, *Physics of the Earth*; Mantle, *Core and Crust*; Stacey, *Physics of the Earth.* (Prerequisite: Open only to III, IV-5g)

PHY 443X THEORY AND APPLICATION OF GEOPHYSICAL METHODS

IV – 5g 2 3 – 11, 2 3 – 11

The lectures stress the physical and mathematical theories of seismic, magnetic, electrical and gravitational methods. Considerable emphasis is placed on Fourier transform methods. The laboratory program stresses the practical methodology and will consist of a 10 day field camp held just before term begins. The cost of food and transportation for this camp will not exceed $40 per student. During term, the data taken in the field camp will be interpreted. Text: Grant & West, *Interpretation Theory in Applied Geophysics*; Griffiths and King, *Appiled Geophysics.*

PHY 450C, PHY 450D QUANTUM THEORY I AND II

IV – 5p 2 – – 8, 2 – – 8

Waves and particles, wave packets, uncertainty principle. Schroedinger equation, expectation values, operators, eigenvalues, eigenfunctions, matrix mechanics, angular momentum, central force problems, Pauli spin theory, identical particles, Pauli principle, applications to atoms and molecules. Zeeman effect. Perturbation theory, secular equations, time dependent perturbation theory, transition probabilities. Charged particles moving in electromagnetic fields, scattering theory. (Prerequisite: PHY 382S)

PHY 451C, PHY 451D STATISTICAL MECHANICS I AND II

IV – 5p 2 – – 8, 2 – – 8

Microcanonical, canonical, and grand canonical distributions, Bose-Einstein and Fermi-

Dirac statistics. Appliations to liquid helium, plasmas, phonons, photons and lattice-gas. Mean field approximation for phase transitions (magnetic systems and gas-liquid transition). Theory of imperfect gases. Density fluctuations. Correlation functions. Kinetic theory of gases and application to irreversible phenomena. Derivation of Boltzmann transport equation for binary collisions and its solution. (Prerequisite: PHY 382S)

PHY 452C, PHY 452D RELATIVITY THEORY I AND II

IV – 5p 2 – – 8, 2 – – 8

Special theory: principle of relativity, Lorentz transformations, Minkowski space, tensor algebra. Relativistic particle dynamics, collision theory. Relativistic field theory, hydro-dynamics, Maxwell field, electrodynamics of material bodies, Klein-Gordon field. General theory: principle of equivalence, general covariance, tensor analysis. Einstein equations, Schwarzschild solution, geodesics, gravitational collapse, black holes. Geo-models, Robertson-Walker metric, mix master universe. (Prerequisite: PHY 382S)

PHY 453C, PHY 453D NUCLEAR PHYSICS I AND II

IV – 5p 2 – – 8, 2 – – 8

General properties of nuclei and the nucleons. Nuclear masses, nuclear binding energy. Nuclear structure, meson theory and quark model. Nucleon-nucleon scattering phenomenology and the nucleon-nucleon force. The deuteron. Shell and collective models of nuclear structure. Nuclear reactions. Alpha decay. Fission. Electromagnetic interactions: gamma decay, photonuclear reactions, electron scattering and electrodisintegration. Weak interactions: beta decay, inverse beta decay. Parity non-conservation and related phenomena. (Prerequisite: PHY 382S)

PHY 454C, PHY 454D HIGH ENERGY PHYSICS I AND II

IV – 5p 2 – – 8, 2 – – 8

Introduction to concepts and experimental methods of high energy or particle physics, with an emphasis on phenomenology. Topics include: particle accelerators and detectors, conservation laws and invariance principles in weak, electromagnetic and strong interactions, scattering theory, the production and decay of boson and baryon resonances, unitary symmetry and particle classification. (Prerequisite: PHY 382S)

PHY 455C, PHY 455D SOLID STATE PHYSICS I AND II

IV – 5p 2 – – 8, 2 – – 8

Crystal lattices, including lattice energies; wave propagation in periodic structures, including diffraction; phonons, thermal properties of solids, including specific heats, free electron theory, energy bands, Fermi surfaces, electronic transport properties, homogeneous semiconductors, superconductivity, magnetism in solids. (Prerequisite: PHY 382S)

PHY 456C, PHY 456D MODERN OPTICS AND RADIATION I AND II

IV – 5p 2 – – 8, 2 – – 8

Production and propagation of electromagnetic radiation. Vectorial nature of light. Coherence and interference including interferometry. Diffraction including holography and the diffraction of x-rays. Optics of solids including nonlinear optics. Masers and lasers. Scattering of light – Rayleigh, Brillouin and Raman. Magnetic resonance – NMR, EPR, NQR. (Prerequisite: PHY 382S)

PHY 457F GROUP THEORY AND ITS PHYSICAL APPLICATIONS I

IV – 5p 2 – – 8

A discussion of abstract group theory and the theory of group representations with some illustrative examples of physical applications. The full rotation group and angular momentum is also included. (Prerequisite: PHY 382S)

PHY 458S GROUP THEORY AND ITS PHYSICAL APPLICATIONS II

IV – 5p 2 – – 8

The application of the techniques of group theory to several detailed topics taken from the fields of atomic, molecular and solid state physics. This course makes use of the material contained in PHY 457F. (Prerequisite: PHY 382S)

PHY 480F MODERN PHYSICS

IV – 3 3 – 19

A discussion of the fundamental principles in atomic and nuclear physics. Emphasis will be given to the application of these principles in branches of modern engineering. Topics will include basic quantum mechanics, atomic and nuclear structure, solid state and the interaction of radiation with matter. Specific items such as x-rays, radioactive decay and the nuclear reactor will be discussed. Textbook: *Modern Physics for Engineers*, Oldenberg and Rasmussen.

STATISTICS

(Department of Mathematics)

STA 282S PROBABILITY AND STATISTICS

II – 3, 8; II – 2, III – 2A (elective) 2 – 28

Elements of probability theory. Binomial, Poisson and normal distributions. Sampling theory. Significance tests. Control charts. Least squares.

STA 287S PROBABILITY AND STATISTICS

II – 5 3 – 1 8

Definition of probability; binomial, Poisson, and normal distribution; frequency; sampling distributions. Examples of estimation, hypothesis testing, control charts, regression, and analysis of variance.

M. Srivastava

STA 291F PROBABILITY

II – 4 2 – 2 8

Elements of probability. Random variables. Discrete and continuous distributions. Moments. Independence. Conditional probabilities. Theory of sampling. (Prerequisite MAT 180F, MAT 181S)

STA 292S STATISTICS

II – 4 2 – 2 8

A continuation of STA 291F. Tests of significance and confidence limits. Control charts. Introduction to the analysis of variance, design of experiments and regression. (Prerequisite STA 291F)

STA 392S PROBABILITY AND STATISTICS

III – 4 2 – 2 8

A continuation of STA 292S. General regression theory. Elements of the theory of sample surveys. (Prerequisite STA 292S)

ADDITIONAL COURSES

The courses listed below are not prescribed for any specific program, but are included in this section to bring them to the attention of interested students who may wish to choose one as an elective subject. The detailed course descriptions can be found in the appropriate calendar containing the listings of the departments offering the courses.

CHE 443	Organic Chemistry	2 3 – 8, 2 3 – 8
STA 347S	Probability and Applications	2 – 1 8

LIST OF IN-HOUSE NON-TECHNICAL ELECTIVES FOR 1973–74

The following in-house non-technical electives will be available to students in all four years in the session 1973–74. Two half courses or one full course may be taken as a non-technical elective by students in their first and second years, and as an open or free elective by students in their third and fourth years. All courses consist of two hours of lectures per week.

These courses will only be offered in a given term if there is sufficient enrolmnt, and the enrolment may have to be limited in some courses.

ECO 281 ECONOMICS
An introduction to the study of Economics with special reference to the problems of the Canadian economy. Those students who obtain a satisfactory term mark will not be required to write the final examination. This course has equivalent value to ECO 100 as a prerequisite for advanced courses in Economics. It may not be combined with ECO 100 or ECO 102 in any degree program.

ENG 281F/S EFFECTIVE WRITING
An "effective" writer knows how to express his ideas clearly and precisely, how to employ the laws of logic in ordering and supporting an argument, and how to use language persuasively. This course will involve discussion of the theory and method of various kinds of writing, supplemented by close consideration of examples of effective prose and by frequent and varied practical exercises designed to develop writing skills.

ENG 282F/S TWENTIETH-CENTURY LITERATURE
This course provides an introduction to twentieth-century literature through a study of representative works of important playwrights, poets, novelists and short-story writers.

ENG 283F/S CANADIAN LITERATURE
This course will deal with representative works of Canadian poets, novelists, short-story writers and essayists, and will consider some of the historical and cultural forces that helped to shape the Canadian imagination.

ENG 384F/S VARIETIES OF FICTION
This course is designed to increase enjoyment and understanding of the various forms of prose fiction (the novel, the novella, the short-story) through close consideration of representative works, including some recently written material.

ENG 285F/S DRAMA AND THE MODERN THEATRE
This course is designed to increase understanding and enjoyment of drama. It will deal with plays (of whatever period) which are still being performed in the contemporary theatre and will consider the reasons for their theatrical effectiveness for modern audiences. Where possible, attention will be given to filmed drama and to plays currently being performed in Toronto.

ENG 286F/S LITERARURE AND SCIENCE
This course will explore some of the ways in which the methods and discoveries of science have made and are making an impact upon literature and will deal with a selec-

tion of the wide variety of works (from metaphysical poetry to science fiction) which were written in response to the scientific and technological ideas of their time.

ENG 287S SPECIAL STUDIES IN ENGLISH

A course intended for students in ENG 281F, 282F, 283F, 284F, 285F, or 286F who may wish to continue studying the subject matter of their Fall-Term course rather than select a different option. Prerequisite: Consent of the instructor.

HPS 280F/S HISTORY OF SCIENCE AND TECHNOLOGY

An introduction and survey to the history of science and technology to show the growth and interaction of the two fields from the earliest times to the XXth century. Ideas originating within the two disciplines will be discussed along with their interactions and external influences.

HPS 281F HISTORY OF TECHNOLOGY AND ENGINEERING UP TO THE INDUSTRIAL REVOLUTION

A treatment of the origins of technology and engineering covering development in the civilizations of the Ancient World, that of Greece and Rome, the Medieval World and the period of the Renaissance. Emphasis will be placed on the developments of techniques and of machines with an indication of the content in which these occur.

HPS 282S HISTORY OF TECHNOLOGY AND ENGINEERING FROM THE INDUSTRIAL REVOLUTION TO THE PRESENT

A treatment of the development of machines and the utilization of new power sources during the period under discussion. The interrelation of new techniques and chemical processes with economic and other factors as well as the interaction between science and technology will be included.

HPS 283S TECHNOLOGY, ENGINEERING AND SOCIETY

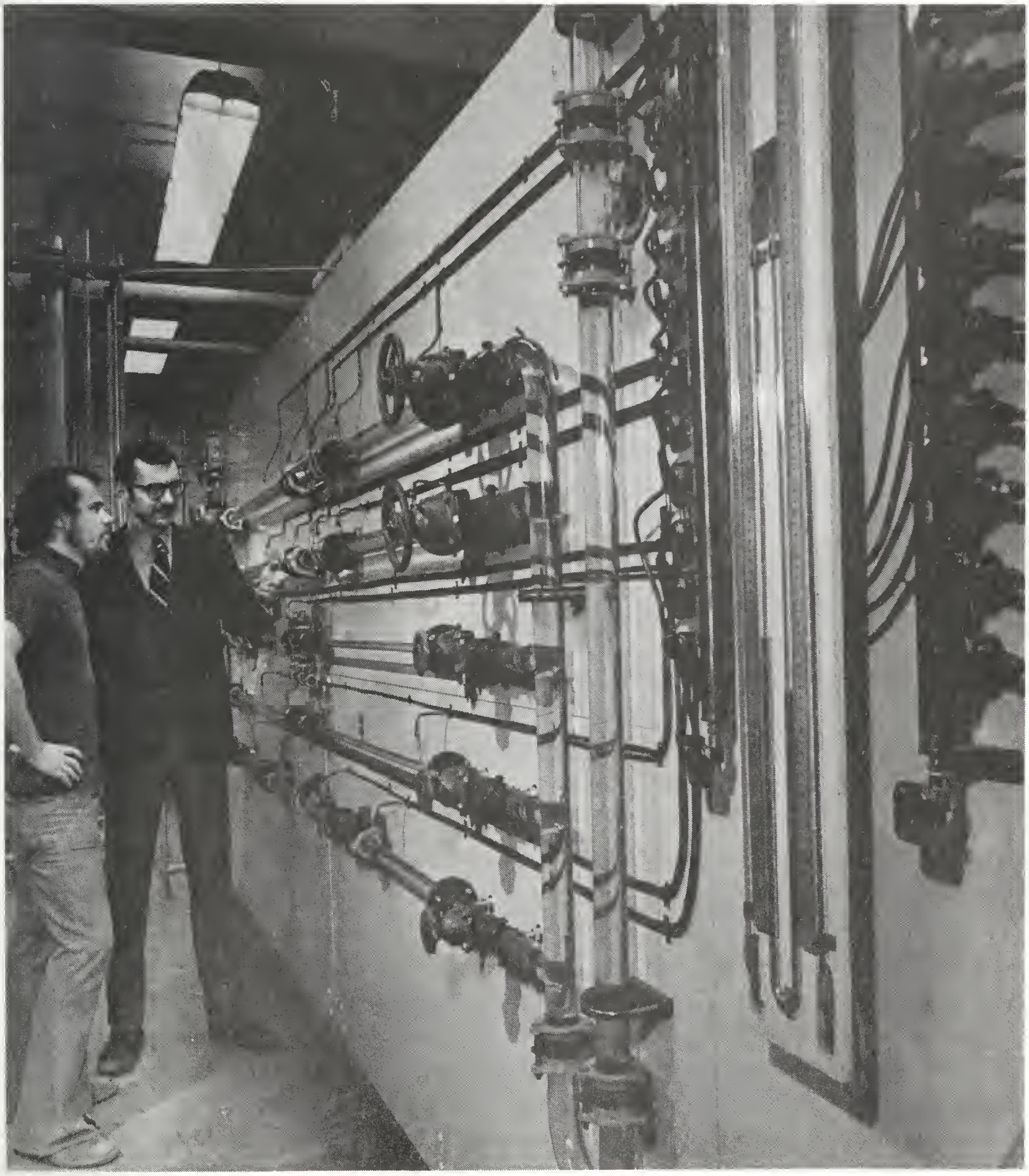
An historical treatment of the interaction of technology, engineering and society. Material will be selected from throughout history, but concentration will be placed on the period since the Industrial Revolution where the nature of society is seen to be highly affected by technological developments and engineering accomplishments. The nature of the technical knowledge which permitted these changes will be discussed along with the adoption of the specific processes, machines and devices. Consideration will be given to the effects of man as a technological innovator on the environment and eco-system, including biological effects. (It is not considered at this time that attendance in this course should be limited, but if presumed attendance is too large for classroom discussion, it will be restructured to meet periodically in small groups.)

PHL 291F SCIENCE AND SOCIETY

A philosophical examination of the role of the scientist, technologist, and engineer in contemporary society, including some of the following problems: pollution, and its control, war research, the "think tank", technocracy, nationalism.

PHL 292S SCIENCE AND PHILOSOPHY

The advance of the physical, social, and life sciences has produced successive changes in concepts familiar to the ordinary man (space and time; cause and effect; man and animal; purpose, motive, freedom). The philosopher has attempted to work out the implications of these changes. This course will examine some of these attempts.



VII

General Regulations; Examinations

The curriculum is based on a term system in which all courses of instruction (with the exception of certain courses taken in the Faculty of Arts and Science) will be one term in duration. There are two terms in the annual session, each concluding with final examinations in the courses offered. With the exception of the First Year, for which there are special provisions, students will be evaluated for promotion at the end of each term.

A regular program consists of a maximum of six courses per term with a total weight of 48 units; with the approval of the Chairman of his Department a student enrolled in the second or higher years may elect to reduce his load to a minimum of 40 units per term, or to increase it to a maximum of 60 units. First-year students may not take less than the normal load of 48 units.

I. DEFINITIONS

Fall Term Average – is calculated on the basis of all courses in which the student is enrolled at the start of the eighth week of the term, with the weighting factor for each course being the units assigned to it. The results of summer* or pre-session courses taken for credit will be included in the calculation of the Fall Term Average with their full unit value. The results of full-year courses taken in another Faculty will not be included in the calculation of the Fall Term Average, except in the case of certain courses for which arrangements have been made for the submission of marks on a term basis.

Spring Term Average – is calculated on the basis of all courses in which the student is enrolled at the start of the eighth week of the term with the weighting factor for each course being the units assigned to it. The results of full-year courses in which there is no mid-year evaluation will be included in the calculation of the Spring Term average with a weight equal to the spring term weight only. When the Fourth Year Thesis is spread over two terms and a department elects to report marks only at the end of the second term, the mark will have a weight equal to the sum of the Thesis weights for the two terms.

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*Approval to take a summer course for credit must be obtained in advance by writing to the Secretary, Faculty of Applied Science and Engineering.

Year Average – is computed on the basis of the *final* marks and weights of all courses in which the student was enrolled in both terms, the weight of full-year courses being the sum of the term weights.

Core Course – Any course in a program that is so designated by a Department.

Evaluation Period – the fall and spring terms taken together is the principal evaluation period for students who are taking First Year for the first time. For all other students, the evaluation period is a single term.

II. REGULATIONS

1. To qualify for a degree, a student must complete a full undergraduate program.

2. (*a*) The normal load is 48 units per term but a student may reduce his load to approximately 40 units or increase it to 60 units if his Department Chairman approves.

(*b*) Certain students are not permitted to reduce their academic loads, viz. students in First Year for the first time, or students who are required to repeat all of the courses in a term of one of the prescribed departmental programs.

(*c*) Students required to repeat courses and to whom regulation 2. (*b*) does not apply must carry a reduced load of approximately 40 units per term.

(*d*) In the final term a student may carry less than the normal minimum load of 40 units if the aggregate weight of the courses required for completion of his program is less than 40 units.

3. A student taking the First Year program in Division A who:

(*a*) Obtains a Fall Term average of 50% or greater proceeds to the next term.

(*b*) Obtains a Fall Term average less than 50% will be required to withdraw until the next Fall Term, at which time he will be re-admitted without petition. Upon re-admission he must repeat* all courses for which his mark was less than 60 and is placed on probation.

(*c*) Obtains a Year Average of 60% or greater proceeds ot the next term.

(*d*) Obtains a Year Average less than 60% but greater than or equal to 55% proceeds to the next term and is placed on probation.

(*e*) Obtains a Year Average less than 55% but greater than or equal to 50% must repeat* all courses from both terms for which his mark was less than 60% and is placed on probation.

(*f*) Obtains a Year Average less than 50% will be required to withdraw. (See regulations 7 and 8.)

4. A student taking the First Year program in Division B who:

(*a*) Obtains a Fall Term Average of 55% or greater proceeds to the next term in Division B.

(*b*) Obtains a Fall Term Average less than 55% but greater than or equal to 50% proceeds to the next term of a program in Division A.

(*c*) Obtains a Fall Term Average less than 50% will be required to withdraw until the next Fall Term at which time he will be re-admitted to Division A without petitioning. Upon re-admission, he must repeat* any course for which his mark was less than 60% and which has an equivalent in Division A and he is placed on probation.

(*d*) Obtains a Year Average of 66% or greater proceeds to the next term.

(*e*) Obtains a Year Average less than 66% but greater than or equal to 55% proceeds to the next term of a program in Division A.

(*f*) Obtains a Year Average less than 55% but greater than or equal to 50% proceeds to the next term of a program in Division A and is placed on probation.

(*g*) Obtains a Year Average less than 50% will be required to withdraw until the next Spring Term at which time he will be re-admitted to Division A without petitioning. Upon re-admission he must repeat* any spring-term course for which his mark was less than 60% and which has an equivalent in Division A and is placed on probation.

5. Any student not covered under Section 3 or 4 who:

(*a*) Obtains a Term Average of 60% or greater proceeds to the next term and, if applicable, is removed from probation.

(*b*) Obtains a Term Average less than 60% but greater than or equal to 55% proceeds to the next term if not already on probation, and is placed on probation.

(*c*) Obtains a Term Average less than 55% but greater than or equal to 50% and is not already on probation is placed on probation and must repeat* all courses taken in that term for which his marks were less than 60%. Normally any student in this category who must repeat more than two of his technical courses will be required to withdraw for one term.

(*d*) Obtains a Term Average less than 50% will be required to withdraw. (See regulations 7 and 8.)

(*e*) To be eligible for graduation a student must attain an average not lower than 60% in his final term; a student who fails to do so must repeat or replace courses to bring his average up to at least 60%.

6. A student will also be required to withdraw from the Faculty if:

(*a*) He is on probation and fails to obtain at least a 60% average so as to remove himself from probation.

(*b*) He has been placed on probation twice before and obtains an average which would place him on probation again.

7. A student who is required to withdraw for the first time under regulations 3. (*f*), 5. (*d*) or 6:

(*a*) Must wait until one full term has elapsed before applying for re-admission.

(*b*) Will be considered for re-admission on his merits in competition with all other applicants.

(*c*) Must repeat,* if re-admitted, all courses taken in his last evaluation period for which his mark was less than 60% and is placed on probation.

8. A student who is required to withdraw for the second time under regulations 3. (*f*), 5. (*d*), or 6. (*a*) will not normally be re-admitted.

9. A student required to repeat courses can make up his academic load of approximately 40 units per term in the following ways, provided that his selections create no timetable conflicts:

(*a*) By taking courses from the next higher year of the program if he has obtained a mark of 50% or greater in the appropriate prerequisites taken in his previous evaluation period.

(*b*) By taking courses of comparable level to his failed courses. Normally these will not relieve the student of completing all the required courses in the program in which he is enrolled.

(*c*) By repeating courses which he has previously completed.

SUMMARY OF REGULATIONS FOR PROMOTION AND FAILURE

A_T = Term Average A_Y = Year Average

Evaluation Period	Average	Decision
Term 1 (First Year)	*Division A*	
	$A_T \geqslant 50\%$	Proceed to next term (Reg. 3a)
	$A_T < 50\%$	Required to withdraw for one term (Reg. 3b)
	Division B	
	$A_T \geqslant 55\%$	Proceed to next term (Reg. 4a)
	$50\% \leqslant A_T < 55\%$	Required to transfer to Division A (Reg. 4b)
	$A_T < 50\%$	Required to withdraw for one term (Reg. 4c)
Term 1 and 2 (First Year)	*Division A*	
	$A_Y \geqslant 60\%$	Proceed to next term (Reg. 3c)
	$55\% \leqslant A_Y < 60\%$	Proceed to next term on probation ** (Reg. 3d)
	$50\% \leqslant A_Y < 55\%$	Repeat* all courses with mark less than 60% and go on probation** (Reg. 3e)
	$A_Y < 50\%$	Required to withdraw (Reg. 3f)
	Division B	
	$A_Y \geqslant 66\%$	Proceed to next term (Reg. 4d)
	$55\% \leqslant A_Y < 66\%$	Proceed to next term in Division A (Reg. 4e)
	$50\% \leqslant A_Y < 55\%$	Proceed to next term in Division A on probation** (Reg. 4f)
	$A_Y < 50\%$	Required to withdraw for one term (Reg. 4g)
All Other Terms	$A_T \geqslant 60\%$	Proceed to next term (Reg. 5a)
	$55\% \leqslant A_T < 60\%$	Proceed to next term on probation** (Reg. 5b)
	$50\% \leqslant A_T < 55\%$	Repeat* all courses with mark less than 60% and go on probation** (Reg. 5c)
	$A_T < 50\%$	Required to withdraw (Reg. 5d)

*Courses which are not designated as core courses need not be repeated but can be replaced by a course of comparable level.

**A student will be required to withdraw if:

(*A*) He is on probation and fails to obtain at least a 60% average so as to remove himself from probation. (Reg. 6a)

(*B*) He has been on probation twice before and obtains an average that would place him on probation again. (Reg. 6b)

GRADING SYSTEM

1. The student's work in individual courses is graded in the following manner:

Marks	*Grade*
80 – 100%	1
70 – 79%	2
60 – 69%	3
50 – 59%	4
Below 50%	5

2. Honour standing in the work of a term or a year is granted to students who achieve a weighted average of 75% or greater.

3. Honour graduate standing will be granted to students who obtain honours in the final year and in any one previous year.

CHECKING OF MARKS

It is a policy of the Faculty that no examination papers or essays will be re-read or re-evaluated after the results have been issued. All results are carefully reviewed before being released. However, the clerical work involved in the examining department and in the Faculty Office will be checked upon written request to the Secretary of the Faculty of Applied Science and Engineering. The request must be accompanied by a fee of $5 for each paper to be checked. The fee will be refunded if an error is found.

ATTENDANCE

1. Students proceeding to the degree are required to attend the courses of instruction and the examinations in all subjects prescribed. A student whose attendance at lectures or laboratories, or whose work, is deemed by the Council of the Faculty to be unsatisfactory may have his registration cancelled at any time.

2. Students must conform to all lecture room and laboratory regulations. Reports, briefs, theses and drawings become the property of the Council to dispose of as it may see fit. Drawings, briefs and field notes will not be accepted unless they have been made at the time and place provided in the time table.

APPEALS

1. A student should submit immediately after its occurrence, evidence of any illness or mishap which occurs during the term; any petition for leniency on account of such incidents may be refused consideration if received after the third day following the last day of examinations.

2. A student wishing to appeal against a decision of a Committee of Council should consult the Secretary of the Faculty for information regarding the appeal processes available within the Faculty.

3. A student wishing to appeal to the Governing Council against a decision of the Council of the Faculty should consult the Secretary of the Faculty or the office of the Governing Council about the preparation and submission of his petition to the Secretary of the Governing Council.

VIII

Medals, Prizes, Scholarships and Bursaries

Through the generosity of friends of the University, governments and commercial organizations, encouragement has been given to undergraduate work in the various branches of engineering study by the establishment of the scholarships, prizes, bursaries and medals listed in the following pages.

ADMISSION SCHOLARSHIPS AND BURSARIES

Ontario Students:
Scholarships and bursaries available to students entering the First Year are listed on page 177. For full details concerning these awards, applicants should consult the Calendar of Admission Awards, which is available at Secondary Schools or from the Office of Student Awards, Simcoe Hall, University of Toronto. Applications, which must be made through the Principal of the Secondary School, close on April 19 annually.

Non-Ontario Students:
All non-Ontario students should apply to the Office of Student Awards, Simcoe Hall, University of Toronto. A limited number of scholarships is reserved for students living outside the Province of Ontario, but as competition is keen such students must not count on receiving assistance but are advised rather to ensure that they have sufficient funds from their own government or from private sources to cover all probable expenses.

IN-COURSE SCHOLARSHIPS AND BURSARIES

Scholarships, prizes, bursaries and loans available to students in attendance in the Faculty are listed on pages 177 to 180. Where it is necessary to make application for an award it is so stated in the description and particulars are given as to how the application should be made. In all other cases the award is made on the recommendation of the Faculty Council and no application is necessary.

GENERAL TERMS AND CONDITIONS

Scholarships, prizes and medals granted in recognition of academic proficiency are awarded at the end of the spring term, the candidates being ranked on the basis of their achievement in the spring term and the fall term previously completed.

To be eligible for any scholarship or award granted solely on academic standing a student must have completed not less than the normal full load within the two terms upon which the award is based. A student whose program in these two terms contains repeated courses will only be eligible if his aggregate of new courses is equal to or greater than 96 units.

Unless otherwise specified in the terms of award, scholarships, medals and prizes based solely upon academic standing will be awarded only to students who have achieved honours in the work upon which the award is granted. If the award is based on a single course or on a part of the work of the term, the candidate must obtain unconditional pass standing in the work of the term, but need not obtain honours on the work of the term unless the terms of the award so specify.

A candidate will not be permitted to hold more than one award in a session unless the statute of each of the awards concerned or the calendar specifies otherwise. Only one of those awards marked with an asterisk may be held in any one year.

Medals, after they have been suitably engraved, will be given without delay to the winners or forwarded to them by registered mail.

Awards granted to members of graduating classes other than awards for graduate study and research, will be paid in one instalment as soon as possible after the granting of the awards.

All other awards will be paid (i) if of the value of $100 or less, in one instalment on November 20 and (ii) if of the value of more than $100 in two equal instalments, the first on November 20 and the second on January 20, in the session following the granting of the awards. Payment will be made only if the candidate is in regular attendance in the Faculty and, if the Calendar so specifies, in the course in which the award is established or granted.

The Governing Council may, on the recommendation of the Faculty, permit a candidate to whom an award has been granted to postpone attendance upon lectures and laboratory classes for one year. Further postponement may be permitted on application.

NOTE – As the value of an endowed scholarship or prize is dependent on the actual income of the fund, it is possible that the value of certain scholarships and prizes at the time of payment may be greater or less than the amount stated in the calendar.

In those cases where the amount of the award is not payable from income earned on an endowed fund, payment will be dependent on the receipt of the amount of the annual award from the donor.

AVAILABLE TO STUDENTS ENTERING THE FIRST YEAR

(† *indicates that application is required*)

Alumni Association War Memorial Scholarships	†	$ 500	page 204
J. P. Bickell Foundation Scholarships	†	$ 500	184
J. W. Billes Admission Scholarships	†		185
Children of War Dead Education Assistance	†		186
Engineering Alumni Centennial Admission Scholarships (7)	†	$1000	188
Grabill Admission Scholarship	†	$ 500	190
Hagarty Memorial Scholarship	†	$ 60	190
The Murray Calder Hendry Scholarship	†	$ 500	191
Roy Jarvis Henry Admission Scholarships (3)	†	$ 500	191
J. Edgar McAllister Foundation Admission Awards	†	$1000	193
Lachlan Dales McKellar Admission Scholarships (2)	†	$ 500	194
George R. Mickle Admission Bursaries	†	$1000	196
O.H.A. War Memorial Scholarship	†	$ 200	197
Ontario Chapter American Society for Metals Bursaries	†	$ 150	182
Ontario Student Awards Program	†		197
A.P.E.O. Admission Scholarship	†	$ 500	198
Regular Officer Training Plan	†		200
Helen E. Rogers Admission Scholarships	†		200
Simpsons-Sears Limited (Northern Ontario) Scholarship	†	$ 100	202
Walter Sterling Admission Scholarships	†		203
U.T.S. Engineering Scholarship	†	$ 250	204
Wallberg Admission Scholarships (6)	†	$1000	204

AVAILABLE TO STUDENTS COMPLETING THE FIRST YEAR

(† *indicates that application is required*)

Baptie Scholarship		$ 175	183
Canadian Bechtel Limited Bursaries	†		183
J. P. Bickell Foundation Scholarships			184
T. H. Bickle Prize		$ 30	184
Crocker Foundation Bursaries	†		187
John M. Empey Scholarship		$ 170	188
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		192
Johnson's Wax Scholarship		$ 800	192
*J. Edgar McAllister Foundation Undergraduate Awards		$1000	193
Garnet W. McKee-Lachlan Gilchrist Scholarship in Engineering Science		$ 110	193
MacLennan – MacLeod Memorial Prize		$ 25	195
Ontario Chapter American Society for Metals Bursaries	†		182
Ontario Student Awards Program	†		197

Paulin Memorial Scholarship		$ 600	197
Procter and Gamble Bursary	†		198
*Professional Engineers Scholarship		$ 250	198
Ransom Scholarship in Chemical Engineering		$ 325	199
Frederick W. Schumacher Scholarship	†		201
S. Ubukata Fund	†		204
*Wallberg Undergraduate Scholarships (2)		$ 500	205

AVAILABLE TO STUDENTS COMPLETING THE SECOND YEAR

(† *indicates that application is required*)

Harvey Aggett Memorial Scholarship		$ 90	181
Ardagh Scholarship		$ 600	182
A.S.H.R.A.E. Bursaries	†		182
Automotive Transport Association Bursary	†		182
Babb Bursary Fund	†		183
Canada Student Loans	†		184
Canadian Bechtel Limited Bursaries	†		183
J. P. Bickell Foundation Bursaries	†		184
J. P. Bickell Foundation Scholarships			184
T. H. Bickle Prize		$ 30	184
Carveth Metallurgical Ltd. Bursary	†	$ 500	186
5T6 Civils Scholarship	†	$ 200	186
Crocker Foundation Bursaries	†		187
Cyanamid of Canada Scholarship		$ 750	187
John M. Empey Scholarship		$ 170	188
J. A. Findlay Scholarship		$ 100	189
Hugh Gall Award		$ 300	190
Hydro-Electric Power Commission of Ontario Bursary	†	$ 500	192
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		192
J. Edgar McAllister Foundation Bursaries	†		192
*J. Edgar McAllister Foundation Undergraduate Awards		$1000	193
Charles Gordon Manning Prize			195
James L. Morris Memorial Prize		$ 175	196
Ontario Chapter American Society for Metals Bursaries and Scholarship	†		182
Ontario Student Awards Program	†		197
*Professional Engineers Scholarship		$ 250	198
*Rhodes Scholarship	†	£1000	199
Frederick W. Schumacher Scholarship	†		201
Edith Tyrrell Memorial Bursary	†	$ 600	203
Wallberg Undergraduate Scholarship		$ 500	205
William R. Worthington Memorial Scholarship		$ 600	205

AVAILABLE TO STUDENTS COMPLETING THE THIRD YEAR

(† *indicates that application is required*)

American Institute of Industrial Engineers Scholarship		$ 150	181
A.S.H.R.A.E. Bursaries	†		182
Babb Bursary Fund	†		183
F. W. Baldwin Prize		$ 75	183
Canada Student Loans	†		185
Canadian Bechtel Limited Bursaries	†		183
J. P. Bickell Foundation Bursaries	†		184
T. H. Bickle Prize		$ 30	184
*Boiler Inspection and Insurance Company Scholarship		$ 300	185
*Chevron Standard Limited Scholarship		$ 500	186
Chemical Institute of Canada Prize		$ 25	186
Cominco Scholarships	†	$ 800	187
Sydney C. Cooper Bursaries	†		187
Crocker Foundation Bursaries	†		187
Dow Chemical of Canada Limited Award		$ 500	188
John M. Empey Scholarship		$ 170	188
E.I.C. Prize		$ 100	189
Engineering Society Semi-Centennial Award		$ 75	189
J. A. Findlay Scholarship		$ 100	189
James Franceschini Foundation Scholarship		$ 300	189
Chester B. Hamilton Scholarship		$ 500	191
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		192
*Jenkins Scholarship in Engineering		$ 200	192
Loan Funds	†		205
J. Edgar McAllister Foundation Bursaries	†		192
*J. Edgar McAllister Foundation Undergraduate Awards		$1000	193
J. A. D. McCurdy Prize		$ 75	193
Alexander MacLean Scholarship		$ 250	195
Ontario Chapter American Society for Metals Bursaries and Scholarship	†		182
Ontario Student Awards Program	†		197
*Professional Engineers Scholarship		$ 250	198
RCE Memorial Scholarship	†	$ 125	200
Rosedale Chapter, I.O.D.E. Award	†	$ 400	201
Don Salt Memorial Scholarships	†	$ 500	201
Murray F. Southcote Scholarship		$ 100	202
Frederick W. Schumacher Scholarship	†		201
Edith Tyrrell Memorial Bursary	†	$ 600	203
Wallberg Undergraduate Scholarship		$ 500	205
C. H. E. Stewart Bursaries	†		203

AVAILABLE TO STUDENTS COMPLETING THE FOURTH YEAR

(† *indicates that application is required*)

			181
Henry G. Acres Medal			182
American Society of Lubrication Engineers Prize		$ 75	184
J. P. Bickell Foundation Bursaries	†		183
Babb Bursary Fund	†		185
Canada Student Loans	†		187
Sydney C. Cooper Bursaries	†		187
Crocker Foundation Bursaries	†		188
Electrical Manufacturing Co. Limited – Montel Inc. Prize		$ 50	205
Loan Funds	†		192
J. Edgar McAllister Foundation Bursaries	†		196
Massey-Ferguson Ltd. Scholarships (2)	†	$ 500	197
Ontario Student Awards Program	†		196
Otto Holden Scholarship		$ 900	198
Professional Engineers Gold Medal			199
J. E. Reid Memorial Prize		$ 50	202
Wallace Award, Society of Automotive Engineers Prize		$ 100	202
Society of Chemical Industry Merit Award			201
"Second Mile Engineer" Award	†	$ 200	205
W. S. Wilson Medals			

HENRY G. ACRES MEDAL

The Henry G. Acres Medal is the gift of Mrs. Henry G. Acres in memory of her late husband, Henry G. Acres, M.E., D.Sc., a graduate of the School of Practical Science in the class of 1903. Throughout his professional life Dr. Acres was associated with major power developments in Canada and abroad. As chief hydraulic engineer for the Hydro-Electric Power Commission of Ontario in the period 1911 to 1923, he was responsible for the design and construction of nearly twenty power plants, including the Queenston-Chippewa development. Entering private practice in 1924, and until his death in 1945, he continued to widen and extend his interests. He became chief engineer of the Grand River Conservation Commission and responsible for the design and construction of the Shand dam and related work. Later, he was consulting engineer for the extensive power developments at Shipshaw on the Saguenay River, which was vital to the production of aluminum for war purposes. Many of the provinces of Canada sought his services and he advised with respect to work in Newfoundland, South America and India.

This medal is awarded annually to the student in the Fourth Year who is registered in the course in Civil, Mechanical, or Electrical Engineering, and who obtains the highest aggregate percentage at the annual examinations of the Third and Fourth Years, provided always that the student obtains honour standing in the examinations of the Fourth Year. Receipt of the medal does not preclude a student from being granted such other award as may in the opinion of the Council be appropriate.

HARVEY AGGETT MEMORIAL SCHOLARSHIP

This scholarship was donated by the late Mr. J. T. Aggett, of Toronto, as a perpetual memorial to his son, the late Lieutenant Harvey Aggett, who enlisted in March, 1915, during his second year in this Faculty, and was killed in action at Passchendaele on November 6, 1917.

This annual scholarship of the value of the annual income from the fund is to be awarded to a student of the Second Year in this Faculty who, obtaining honours and being one of the first three in his year by his standing at the annual examinations, has been adjudged highest of the three in general student activities and service in the University during his period of attendance. When regulations do not permit the winner to hold this scholarship the students to be considered for the award shall be the first three in the year exclusive of any student who holds a scholarship of higher value.

AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS SCHOLARSHIP

The Toronto Chapter, American Institute of Industrial Engineers offers a scholarship of $150 to a student entering the Fourth Year of the Industrial Engineering course who has consistently maintained a high academic standing, but not necessarily honour standing, during the previous three years.

A.S.H.R.A.E. BURSARIES

The Ontario Chapter of the American Society of Heating, Refrigerating and Air-Conditioning Engineers provides a number of bursaries, to a total value of $1500 annually, for students in the Second and Third Years of Electrical Engineering and Mechanical Engineering. Candidates must reside in Metropolitan Toronto or in an adjacent municipality; the awards will vary in value, according to individual need and the fund available. Application should be made to the Secretary of the Faculty by October 15, on the regular in-course bursary application form.

AMERICAN SOCIETY OF LUBRICATION ENGINEERS PRIZE

The Toronto section of the American Society of Lubrication Engineers offers an annual prize of $75 to a student in the Fourth Year in Mechanical Engineering whose Thesis dealing with Lubrication is considered by the Head of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory. The Prize is accompanied by a donation of $25 to the Department to purchase books on Lubrication.

ONTARIO CHAPTER, AMERICAN SOCIETY FOR METALS BURSARIES AND SCHOLARSHIP

The Ontario Chapter, American Society for Metals, provides several bursaries of a value of $150 each for students in all years of Metallurgy and Materials Science and in the Third and Fourth Years of the Materials Science option of Engineering Science. Bursaries are awarded on the basis of academic ability and the need for financial assistance. Applications should be made to the Secretary not later than October 1st. The first award was made for the Session 1958–59.

The Ontario Chapter also provides one scholarship of a value of $250 for academic excellence to be awarded to a student in Metallurgy and Materials Science after completion of the Second or Third Year or the Materials Science option of Engineering Science (Third Year). The first award was based upon the results of examinations in the Session 1970–71.

ARDAGH SCHOLARSHIP

The Ardagh Scholarship, of the annual value of the income from $7,500, has been provided in memory of his parents by Professor E. G. R. Ardagh, B.A.Sc., F.R.S.C., formerly professor of Applied Chemistry in the Faculty. It is awarded to the student who attains the highest standing with Honours at the annual examination of the Second Year in the Course in Chemical Engineering. The first award was made on the results of the annual examination of 1946.

ATA TRUCKING INDUSTRY EDUCATIONAL FOUNDATION BURSARIES

The Automotive Transport Association of Ontario has established a bursary fund for students in the second or higher years of any undergraduate degree course who find themselves in serious financial need due to sudden, unexpected personal or family difficulties. Applications may be submitted to the Office of Student Awards at any time during the session and the number and value of the bursaries will vary at the discretion of the Committee of Award.

THE BABB BURSARY FUND

Bursaries from this fund are available to students in any year of the Aeronautics Option in Engineering Science. Application is made through the Secretary of the Faculty.

THE F. W. BALDWIN PRIZE

The F. W. Baldwin Prize of a value of $75 was established by the trustees of a fund created by the members of the Number 3 Squadron, University Air Training Corps (1941–44), in memory of Frederick Walker "Casey" Baldwin, a graduate of the School of Practical Science, who made a significant contribution in the field of Aeronautics in Canada; and who flew, on March 12, 1908, near Hammondsport, N.Y., the "Redwing," the first biplane built by the Aerial Experiment Association.

It is awarded annually to the student registered in Third Year, Aeronautics Option, in Engineering Science, who, taking honours, ranks highest in the annual examinations of Third Year in "structural subjects."

The first award was made on the results of the examinations of the Session 1953–54.

BAPTIE SCHOLARSHIP

The Baptie Scholarship is derived from a bequest under the will of the late Mrs. Margaret W. Baptie, of Ottawa, and the Board of Governors has directed that a scholarship of one half the annual income shall be awarded annually to an engineering student on the record of the first Year. The Board of Governors also authorizes a remission of fees in the case of the holder of the scholarship, up to $75.

The conditions of the award are as follows: That the scholarship be awarded to the student who, in the annual examinations of the First Year, enrolled in any one of the courses of Civil Engineering, Mechanical Engineering, Chemical Engineering, Electrical Engineering, or Metallurgy and Materials Science, obtains the highest aggregate percentage of marks in those subjects which are common to the First Year curricula of those courses. The first award was made on the results of the annual examinations of the Session 1925–26.

CANADIAN BECHTEL LIMITED BURSARIES

Canadian Bechtel Limited has established Bursaries in the Faculty of Applied Science and Engineering of an annual value of $1,200 to provide not more than four awards, each of a minimum value of $200 and a maximum value of $600. Two awards will be made to First Year students and one or two awards to students registered in any year of the Faculty. Applicants must demonstrate financial need and have academic standing satisfactory to the Faculty Council.

Application must be made to the Secretary of the Faculty on or before October 1.

J. P. BICKELL FOUNDATION SCHOLARSHIPS

The Trustees of the J. P. Bickell Foundation have established scholarships, the number to be determined annually, in the Faculty of Applied Science and Engineering of a possible value of $1,500 payable $500 in the First Year and provided honours are obtained at the Annual Examinations, $500 in the Second and Third Years.

An applicant must obtain an average of at least 75% at the Ontario Grade XIII examinations immediately preceding his admission to the university and must undertake to enrol in Chemical Engineering, Metallurgy and Materials Science or Geological Engineering. Failing suitable candidates in the courses mentioned students registered in the Second Year Honour course in Geological Sciences, or Physics and Geology in the Faculty of Arts and Science who are academically qualified are eligible. These awards are of the same value and are tenable in the Second, Third and Fourth Years of the course, subject to maintenance of the required academic standing. If any scholarships are not awarded to those mentioned above, students registered in the Third Year of the Engineering Science course in the Faculty of Applied Science and Engineering and taking the Physical Metallurgy or the Geophysics option who are academically qualified are eligible. In this case the scholarship will have a value of $1,000, payable $500 in each of the Third and Fourth years, provided the required academic standing is maintained.

Applications from those entering First Year must be submitted to the Office of Student Awards not later than May 1 on the regular admission scholarship application form. In other cases, applications are not required.

J. P. BICKELL FOUNDATION BURSARIES

The Trustees of the J. P. Bickell Foundation have established the J. P. Bickell Foundation Bursaries in the Faculty of Arts and the Faculty of Applied Science and Engineering. An applicant must be enrolled in Honour Science or in Mathematics, Physics and Chemistry in the Faculty of Arts, in which case he must undertake to study mining or geology in his higher years; or be enrolled in a higher year of an honour course in the geological or geophysical field in the Faculty of Arts; or be enrolled in Chemical Engineering, Mining Engineering, Metallurgy and Materials Science, or Geological Engineering in any year of the Faculty of Applied Science and Engineering. He must demonstrate financial need and have satisfactory academic standing.

Application must be made to the Office of Student Awards on or before October 15.

THE T. H. BICKLE PRIZE

The T. H. Bickle Prize is the gift of Mr. and Mrs. E. W. Bickle in memory of their son, T. H. Bickle, an undergraduate of Trinity College and a member of the Senior Intercollegiate Swimming Team at the time of his death in 1937. The income from the endowment fund will be used to purchase a suitable prize to be awarded annually to a member of the Senior Intercollegiate Swimming Team of this University in any year, faculty or school. The Committee of Award shall consist of the Dean of the Faculty of Arts, the Director of Athletics, and the Honorary Coach of Swimming. In awarding the Prize the Committee shall consider the character, scholarship, and general interests of the members of the team.

J. W. BILLES ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of J. W. Billes, open to students entering any degree course in the University. The value in each year is a minimum of $250 and a maximum of $1,500 dependent upon the financial need of the recipient. Applicants must satisfy the normal admission scholarship standards in their Grade XIII examinations to be eligible for an award and maintain first class honour standing to enjoy the scholarship in higher years. The number of scholarships awarded in any one year may be varied dependent upon the available funds.

Application should be made to the Office of Student Awards by April 19 on the regular admission scholarship application form.

BOILER INSPECTION AND INSURANCE COMPANY SCHOLARSHIP

The Boiler Inspection and Insurance Company of Canada offers a scholarship in the Course in Mechanical Engineering of the value of $300 to the student who obtains highest honour standing in the regular examinations of the Third Year.

The successful candidate will be expected to proceed to his Fourth Year during the session next following the date of the award.

The amount of the award will be credited by the Chief Accountant to the fees of the Fourth Year of the successful candidate.

CANADA STUDENT LOANS PLAN

Full details of this Plan are available in a brochure issued each spring by the Government of Canada. Basically, the Plan is designed for those students who have resided in Canada for twelve months and demonstrate financial need, but who do not qualify for assistance under the Ontario Student Awards Program. Effective 1972, the maximum Canada Student Loan is $1,400 per academic year. The application form for the Ontario Student Awards Program is also used for the Canada Student Loans Plan.

Application forms and brochures are available from the University of Toronto, Office of Student Awards, and all other post-secondary institutions, and should be submitted to the institution which the student plans to attend.

Students who intend to study outside Ontario or abroad should apply through the Ministry of Colleges and Universities, Mowat Block, Queen's Park, Toronto, Ontario.

CHEVRON STANDARD LIMITED SCHOLARSHIP

Chevron Standard Limited has presented a scholarship of $500 to a student who achieves outstanding results in the annual examinations of the Third Year in the Geophysics Option in Engineering Science or in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and Science.

The awards alternate annually between the Faculties of Applied Science and Engineering and Arts and Science and the First Award was made in the session 1960–61 in the Faculty of Applied Science and Engineering.

CARVETH METALLURGICAL LTD. BURSARY

Carveth Metallurgical Ltd. provides one or more bursaries to a total value of $500 for students entering the Third Year of Metallurgy and Materials Science. The award is made primarily on the basis of Second Year standing, but the need for financial assistance will also be taken into consideration.

The Bursary is available every third year, beginning in the Session 1961–62, and is to be awarded on the recommendation of the Department of Metallurgy and Materials Science. Application should be made by letter to the Secretary of the Faculty of Applied Science not later than September 1 of the year in which the award is tenable.

CHEMICAL INSTITUTE OF CANADA PRIZE

The Chemical Institute of Canada offers a prize of the annual value of $25 in books to the student registered in the course in Chemical Engineering who, having obtained honours, receives the highest standing in the written and laboratory work of the Third Year.

The first award was made on the results of the final examinations of 1947.

CHILDREN OF WAR DEAD (EDUCATION ASSISTANCE) ACT

Children of War Dead (Education Assistance) Act provides fees and monthly allowances for children of veterans whose death was attributable to military service. Enquiries should be directed to the nearest District Office of the Department of Veterans Affairs.

5T6 CIVILS SCHOLARSHIPS

The 5T6 Civils, consisting of the graduating members of the 1956 Civil Engineering Class of the University of Toronto, have established an annual scholarship of the value of $200 open to students who have completed the Second Year of the course in Civil Engineering and are registered in the Third Year of the course. The selection of the recipient is based on evidence of the qualities of scholarship, leadership and character. The award is not tenable with any other scholarship of greater value.

The award is presented at the annual reunion of the Class of 5T6 Civils. The first award was made in 1964.

Students who wish to be considered for this scholarship should write to the Class of 5T6 Civil Engineering, c/o Alumni House, University of Toronto, not later than December 31, giving full particulars of their academic record, and their extra-curricular activities both within and outside the University.

COMINCO SCHOLARSHIPS

Two scholarships, of an annual value of $800 each, are provided by Cominco Limited and are offered to student in the Third Year of the courses in Chemical Engineering, Geological Engineering, Mechanical Engineering and Metallurgy and Materials Science in the Faculty of Applied Science and Engineering and to students in the Third Year of the courses in Chemistry and Geology in the Faculty of Arts and Science, the awards being made on the basis of the examination results of the Second Year. The scholarships may be renewed in the Fourth Year if satisfactory standing is maintained.

Application must be made to the Secretary of the Faculty on the regular in-course awards form not later than October 15.

SYDNEY C. COOPER BURSARIES

An amount of $900 is provided annually for bursaries to be awarded to students in the Third and Fourth Years of the program in Civil Engineering who have achieved at least second-class standing in the previous year and who are in need of financial assistance.

Application must be made on the regular in-course bursary application form not later than October 15.

CROCKER FOUNDATION BURSARIES

The income from a capital fund established from the estate of the late Beatrice Crocker Glazier in memory of her brother, James William Crocker, provides bursaries for students in the Faculty of Medicine and the Faculty of Applied Science and Engineering who are in need and are worthy of financial assistance.

Application should be made to the Secretary of the Faculty not later than October 15.

CYANAMID OF CANADA SCHOLARSHIP

As a part of their program to encourage technical development in Canada, Cyanamid of Canada Limited offers a scholarship of the value of $750 to a student entering the Third Year in Chemical Engineering or Industrial Engineering. The award is made to a student who has demonstrated high academic ability and outstanding scholarship in the work of the Second Year.

The first award at the University of Toronto was made in 1964.

DOW CHEMICAL OF CANADA LIMITED AWARD

Dow Chemical of Canada Limited have provided funds for an annual award of $500 to a student in Chemical Engineering in the Faculty of Applied Science and Engineering, and grant-in-aid of $250 to be used in the winner's department to help defray the cost of equipment, supplies and administration.

The winner must:

(*a*) be registered in the Third Year in Chemical Engineering (the award will be made in the second term of the Third Year and will be paid to the winner during his Fourth Year);

(*b*) be in the upper half of the class;

(*c*) have demonstrated leadership in extra-curricular activities.

The award is not tenable with other awards in the gift of the Governing Council. Application is not required.

THE ELECTRICAL MANUFACTURING COMPANY LTD. – MONTEL INC. PRIZE

The Electrical Manufacturing Company Limited has established an annual Prize of $50 in the Faculty of Applied Science and Engineering.

The winner must:

(*a*) be registered in the Fourth Year in Electrical Engineering;

(*b*) obtain the highest aggregate percentage of marks at the final examinations in the subjects of the Fourth Year related to electrical distribution equipment, the subject to be determined by the Head of the Department of Electrical Engineering.

This Prize is tenable with other awards in the gift of the Governing Council.

THE JOHN M. EMPEY SCHOLARSHIPS

The John M. Empey Scholarship Fund was established under a bequest of $10,000 in the Will of the late John Morgan Empey, B.A.Sc., 1903. Three scholarships of equal value are provided from the income from the Fund. One of these scholarships is awarded in each of the First, Second, and Third Years on the results of the annual examinations, to a student who, taking honours, obtains the highest average percentage of marks in the written and laboratory subjects of his Year. The scholarships are open to any students registered in the Faculty. In case the winner of any one of these scholarships does not attend this Faculty during the session next following the award, the right to the scholarship shall be forfeited and the award shall be made to another eligible student. The scholarships were awarded for the first time in 1944.

ENGINEERING ALUMNI CENTENNIAL ADMISSION SCHOLARSHIPS

Seven scholarships, each of the value of $1000, are provided annually by the University of Toronto Engineering Alumni Association for students entering the first year of any course in the Faculty of Applied Science and Engineering. The awards are made on the basis of standing in the Ontario Grade XIII examinations.

Application should be made to the Office of Student Awards by April 19 on the regular admission scholarship application form.

ENGINEERING INSTITUTE OF CANADA PRIZE

The Engineering Institute of Canada Prize, of the value of $100, is awarded annually to a Student Member of the Institute on the basis of the marks made at the completion of his penultimate year of undergraduate study, and on his activities in the Engineering Society or in the student branch of a recognized engineering Institute or similar organization.

ENGINEERING SOCIETY SEMI-CENTENNIAL AWARD

The Engineering Society Semi-Centennial Award, to the value of $75 was established in 1931 to commemorate the semi-centennial of the founding of the "School." The award is made to a student entering the final year.

The selection is based upon the following qualifications, which bear equal weight in the selection of the winner: (*a*) General "School" activities. (*b*) Contributions to the Engineering Society Executive Committee. (*c*) Personality, and social and athletic activities. (*d*) Academic standing.

J. A. FINDLEY SCHOLARSHIPS

These scholarships were established through a legacy bequeathed by the late Miss Janet Findlay to the Department of Mechanical Engineering. Two scholarships are available, each of a value of one half of the income of the fund, to students in this Course, one for a student in the Third Year, the other for a student in the Fourth Year, but only if the student continues his course in Mechanical Engineering. The selection will be made, on recommendation of the Head of the Department of Mechanical Engineering, from amongst the four students having the highest average percentage of marks at the annual examinations in the Second and Third Years respectively, but in making the award the student's general character, fitness for his profession, and financial circumstances will be given consideration. In case a student who has been awarded one of the scholarships changes his course or does not attend this University during the next following session, he shall forfeit his right to the scholarship and the award shall be made to another eligible student.

THE JAMES FRANCESCHINI FOUNDATION SCHOLARSHIP

This scholarship, of a value of $300, is awarded to the student in Civil Engineering who achieves the highest standing, with honours, at the annual examinations of the Third Year among those who do not hold an award of a value of $100 or more based on the results of these examinations.

HUGH GALL AWARD

The Hugh Gall Award was established in 1946 by the Graduate Class of 1910 "to commemorate a deceased classmate who was a splendid type of student, a loyal friend, and nationally outstanding in athletic achievement during his undergraduate career." Upon expiration of the original gift in 1951 the award was supported by Mrs. Hugh Gall until her death in 1970; under the terms of her will a sum of $5,000 was provided to support the award in perpetuity, the annual value of the award being the income from the bequest. The award is made to a student who, having completed his First Year with a general average of at least 66% without conditions, has entered the Second Year, and is in special need of financial assistance in order to enable him to continue his course. It is desirable, but not necessary, that the recipient shall not already have been given any other scholastic award or scholarship applicable to the second year and he shall have shown indications of his firm intention and ability to follow successfully the profession of engineering.

Any second year student in the Faculty of Applied Science and Engineering is eligible to apply for this Bursary. Applications should be made to the Secretary of the Faculty not later than October 15.

THE GRABILL ADMISSION SCHOLARSHIP

The Grabill Admission Scholarship is the gift of Mr. Dayton L. Grabill, a graduate of this Faculty in 1924. The Scholarship has a value of approximately $500. It is awarded to the candidate who has standing amongst those with the highest average percentages in the subjects of Ontario Grade XIII required for admission to the Faculty of Applied Science and Engineering. The candidate must write the Grade XIII examinations at one sitting in the June preceding entry to the University after not more than one years' instruction in Grade XIII and must register in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards on the regular Admission Scholarship form by April 19.

THE REGINALD AND GALER HAGARTY SCHOLARSHIP

The Reginald and Galer Hagarty Scholarship, in memory of the dearly beloved sons of Lieutenant-Colonel E. W. Hagarty, B.A. 1883, M.A. 1908, and Charlotte Ellen Hagarty, his wife. Reginald Edward Walter Hagerty, B.A.Sc. (Honours) 1908), a graduate of the University in the Faculty of Applied Science and Engineering and at the time of his death on April 29, 1925, a Consulting Structural Engineer. Lieutenant Daniel Galer Hagarty, Princess Patricia's Canadian Light Infantry, a member of the class of 1916 in Applied Science, enlisted for the Great War at the end of his third year in June, 1915, killed in action in Sanctuary Wood, June 2, 1916. The scholarship is given in recognition of the fact that their father was an honour graduate in Classics of the University of Toronto. It is of the value of the annual interest on the capital sum of $2,000 and is to be awarded to a student who has been enrolled for his Grade XIII Year at Harbord Collegiate Institute and having obtained at least the required standing in each of the Grade XIII subjects necessary for admission to the Faculty, obtains the highest standing in English, a language other than English, and Mathematics, among the students who apply for the award from the Collegiate. He will be required to: (*a*) register in the Faculty of Applied Science and Engineering, (*b*) sign a declaration to the effect that he is willing to take up arms in the defence of Canada and the British Commonwealth should necessity arise as declared by the Parliament of Canada. The Scholarship was offered for award for the first time in 1945. Application should be made to the Office of Student Awards on the regular admission scholarship application form not later than April 19.

CHESTER B. HAMILTON SCHOLARSHIP

Members of the family of the late Chester B. Hamilton, a graduate of the Faculty in 1906, have presented a Scholarship in his memory of the annual value of $500. It is held by a Fourth Year student in Mechanical Engineering who has achieved outstanding academic standing at the Annual Examinations of the Third Year.

The first award was made on the results of the examinations for the Session 1958–59.

THE MURRAY CALDER HENDRY SCHOLARSHIP

This award was established by the estate of Mrs. Grace Appel Hendry as a memorial to her husband, a graduate of this Faculty in 1905. It has a value of the income from a capital sum of $10,000 and the recipient must:

(*a*) have attained an average of at least 75% on the grade XIII examination papers, written at one sitting, required for admission to the Faculty.

(*b*) be entering the First Year of any course in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards by May 1 on the regular University Admission Scholarship Application form.

The first award was made in the Session 1962–63.

ROY JARVIS HENRY ADMISSION SCHOLARSHIPS

The estate of the late Roy Jarvis Henry provides three scholarships of the value of $500 each, to be awarded to students who have achieved high standing on the Ontario Secondary School qualifications required for admission, two of which are open to students entering any course in the Faculty and one open to students entering Geological Engineering. In the lack of a suitable candidate in Geological Engineering, all three awards are tenable in any course in the Faculty. Application must be made on the regular admission scholarship application form.

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO BURSARY

The Hydro-Electric Power Commission of Ontario has provided a bursary of the value of $500, which may be awarded to a student entering the second year of the courses in Mathematics and Physics or Commerce and Finance in the Faculty of Arts and Science, or any course in the Faculty of Applied Science and Engineering. Application should be made on the regular in-course bursary form not later than October 15.

IBM – THOMAS J. WATSON MEMORIAL BURSARY FUND

International Business Machines Company Limited has made available one or more bursaries of a total annual value of $1,000 to students registered in any year of a full time course in the university who have standing satisfactory to the committee of Award and demonstrate financial need.

Application should be made to the Office of Student Awards by October 15.

JENKINS SCHOLARSHIP

The Jenkins Scholarship, presented by Jenkins Bros., Limited, Montreal, first awarded in 1925, has been donated to continue indefinitely.

This Annual Scholarship, of the value of $200, is awarded to the student of the Third Year registered in any course of the Faculty who has the highest aggregate of percentages for the First, Second and Third Years.

JOHNSON'S WAX SCHOLARSHIP

S. C. Johnson and Son Limited, Brantford, Ontario, have established a Scholarship of an annual value of $800 in each of the Second, Third and Fourth Years or a total possible value of $2,400.

The recipient must:

(*a*) be registered in Chemical Engineering in the years in which the Scholarship is awarded and held;

(*b*) in the opinion of the Council be the most promising and deserving member of the class, obtaining Honours in the final examinations of the First Year;

(*c*) in his Second and Third Years, maintain academic standing satisfactory to the Council, not necessarily Honours, for the continued enjoyment of the Scholarship. In its discretion the Council may recommend the award of any portion of the Scholarship, lost by the original recipient by failure to maintain satisfactory academic standing, to another student of the year(s) in which the Scholarship would otherwise have been enjoyed.

The first award was made on the results of the annual examinations written in April 1954. It is not tenable with any other Scholarship.

J. EDGAR MCALLISTER FOUNDATION BURSARIES

Through the generosity of the late J. Edgar McAllister, a graduate of the Faculty in 1895, a fund has been established in the University to be known as the J. Edgar

McAllister Foundation, to provide financial aid for students who require it, in Mechanical, Chemical, Electrical and Geological Engineering and Metallurgy and Materials Science. Application should be made on the regular in-course bursary form not later than October 15.

J. EDGAR MCALLISTER FOUNDATION ADMISSION AWARDS

Provided for by the bequest of the late J. Edgar McAllister, B.A.Sc., twenty-five awards of the value of $1000 each are available to students entering the First Year of the programs in Mechanical, Chemical, Electrical and Geological Engineering and Metallurgy and Materials Science, who have achieved high standing in the secondary-school courses prescribed for admission and who are in need of financial assistance.

Applicants wishing to be considered for these awards should complete the financial need section on the regular University of Toronto Scholarship Application form, which is to be submitted not later than April 19.

J. EDGAR MCALLISTER FOUNDATION UNDERGRADUATE AWARDS

Provided for by the bequest of the late J. Edgar McAllister, B.A.Sc., five awards of $1,000.00 each are available to students entering the Second Year in Chemical, Electrical, Geological and Mechanical Engineering, and Metallurgy and Materials Science, who have achieved honours standing in the work of the preceding year. Normally one award will be made in each of the eligible programs, but in the absence of a suitable candidate in a particular program, two awards may be made in another. The bequest also provides for five awards to students entering third Year, and five to students entering the fourth year of these programs, on the same terms.

These awards are not tenable with any other scholarships.

THE J. A. D. MCCURDY PRIZE

The J. A. D. McCurdy Prize of a value of $75 was established by the trustees of a fund created by the members of the Number 3 Squadron, University Air Training Corps (1941–44) in honour of John Alexander Douglas McCurdy, a graduate of the School of Practical Science, who "made the first flight in Canada on February 23, 1909, with a heavier-than-air machine."

It is awarded annually to the student registered in Third Year, Aeronautics Option, in Engineering Science, who, taking honours, ranks highest in annual examinations of the Third Year in the subjects related to Aerodynamics.

The first award was made on the results of the examinations of the Session 1953–54.

THE GARNET W. MCKEE-LACHLAN GILCHRIST SCHOLARSHIP IN ENGINEERING SCIENCE

Mrs. Garnet W. McKee and Professor Lachlan Gilchrist each contributed $1,000 to provide for a Scholarship in the First Year of the Course in Engineering Science.

The value of the Scholarship is the annual income from the capital fund and is awarded to the student who ranks first in honours at the annual examinations of the First Year in the Course in Engineering Science. If for any reason that student is ineligible to hold the Scholarship, it will be awarded by reversion to the student ranking second in honours in the Course. In order to receive payment the winner must register in the Second Year of the Course in Engineering Science. The Scholarship was awarded for the first time on the results of the annual examinations of 1947.

THE GARNET W. MCKEE-LACHLAN GILCHRIST GEOPHYSICS SCHOLARSHIPS

Financial assistance was received by Professor Lachlan Gilchrist of the Department of Physics, University of Toronto, from certain organizations and individuals to help him in the prosecution of his research work in Geophysics. With the consent of the contributors, the unexpended balance of these gifts was transferred by Professor Gilchrist to the Board of Governors of the University to be used as an endowment for scholarships, two of which were established in the Faculty of Applied Science and Engineering. To this fund have been added additional amounts received from the estate of the late Garnet W. McKee and from the Hollinger Consolidated Gold Mines Ltd. They are awarded by the Governing Council, on the recommendation of the Council of the Faculty of Applied Science and Engineering. The first awards were made on the results of the Annual Examinations of 1941.

The First Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $200 is awarded to the student in the Second Year in the Course of Engineering Science who obtains the highest aggregate standing at the examinations of the First and Second Years in the Course, provided always that the student obtains honour standing at the examinations of the Second Year.

The Second Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $165 is awarded to the student in the Second Year in the Course of Engineering Science who, of those students who elect to proceed in the Third Year in the Geophysics Option of the Course, obtains the highest aggregate standing at the examinations of the First and Second Years, provided always that the student obtains honour standing at the examinations of the Second Year, and excluding always the student to whom the First Lachlan Gilchrist Geophysics Scholarship has been awarded.

If in any year there is no student who has fulfilled the condition as laid down for the Second Lachlan Gilchrist Geophysics Scholarship, it shall be awarded to the student in the Second Year in the Course in Engineering Science who obtains the second highest aggregate standing at the examinations of the First and Second Years of that Course, provided always that such student obtains honour standing in the examinations of the Second Year.

LACHLAN DALES MCKELLAR ADMISSION SCHOLARSHIPS

Provided by a bequest of the late Leona D. McKellar, two scholarships of the value of $500 each, are offered to students who have achieved high standing on the Ontario Secondary School qualifications required for admission to the Faculty. Application must be made on the regular admission scholarship application form.

THE ALEXANDER MACLEAN SCHOLARSHIP

This scholarship was established by graduates of the University of Toronto and other friends in honour of Professor Alexander MacLean, B.A. (1908) who retired in 1954. The scholarship, of the value of $250, is awarded to a student in the Third Year of Geological Sciences, Faculty of Arts, or in the Third Year of Geological Engineering, Faculty of Applied Science and Engineering, who, obtaining not less than 75% in the work of the year, obtains the highest standing in the geological subjects common to the two courses.

The first award was made in 1955.

MACLENNAN-MACLEOD MEMORIAL PRIZE

The Graduating Class of 1910 has donated an annual prize, known as "The MacLennan-MacLeod Memorial Prize," in memory of their first Class President, George MacLennan, who was killed in action in France in 1917, and of Doug. MacLeod, their first Secretary, who died in France in 1916 from wounds received in action.

The prize, of the value of $25, is awarded to the First Year student in the Faculty of Applied Science and Engineering who ranks highest in Calculus among those who obtain standing without condition at the annual written examinations; or, in the event of more than one student obtaining equally high rank in Calculus, the award is made to the one of these who also has the highest standing in some other subject common to the competitors, such as Algebra, such subject to be determined by the Council of the Faculty.

An award will not be made in any year in which, in the opinion of the Council, no student obtains a sufficiently high standing in Calculus to merit the award. If in any year no award is made, a second award will be available in the subsequent year.

CHARLES GORDON MANNING PRIZE

The Charles Gordon Manning Prize was established by a bequest under the Will of the late Jennie Manning in the amount of $500, the annual income from which is to be used to buy books for the winner of the Prize.

The recipient must be enrolled in the Second Year of a course offered by the Faculty of Applied Science and Engineering and, in the opinion of the Council, rank second to the student awarded the Harvey Aggett Memorial Scholarship in the considerations specified for the award of that Scholarship, namely, obtaining honours in his final examinations and being one of the first three in his year by his standing at those examinations relative to the pass requirements in his Department and being "adjudged highest of the three in general student activities and service in the University during his period of attendance."

The first award was made on the results of the annual examinations of 1954.

MASSEY-FERGUSON LIMITED SCHOLARSHIPS

Massey-Ferguson Limited has established two scholarships each of an annual value of $250, to be awarded on the recommendation of the Council of the Faculty of Applied Science and Engineering to students registered in the Fourth Year of the Courses in Mechanical Engineering or Industrial Engineering. In making the award academic achievement, financial need, extra-curricular activities and such other factors as may be deemed appropriate will be taken into consideration.

Application should be made to the Secretary of the Faculty not later than October 15.

GEORGE R. MICKLE ADMISSION BURSARIES

Provided for by a bequest of the late George R. Mickle, five bursaries of the value of $1000 each are available to students entering the First Year of courses in the Faculty of Applied Science and Engineering. The awards are made on the basis of the applicant's academic standing in Grade XIII, and his need for financial assistance. Applicants wishing to be considered for these awards should complete the financial need section on the regular University of Toronto admission awards application form.

JAMES L. MORRIS MEMORIAL PRIZE

The James L. Morris Memorial Prize is the gift of Mrs. J. H. Craig and Mr. J. R. Morris, K.C., in memory of their father, James L. Morris, C.E., O.L.S., D.Eng., the first graduate of the School of Practical Science, who died in 1946 after a distinguished career. Graduating in Civil Engineering in 1881 as the sole member of his class, Dr. Morris engaged in railway work for some time, first as an engineer and then as a contractor. For 43 years he conducted a successful civil engineering practice in Pembroke, Ontario, involving important undertakings in the field of municipal power and bridge work.

This Prize, of the value of the annual income from $3,000, is awarded annually to the student in the Second Year of the Course in Civil Engineering who obtains the highest aggregate percentage at the annual examinations of the First and Second Years of the course, provided always that the student obtains honour standing at the Examinations of the Second Year.

OTTO HOLDEN SCHOLARSHIP

Otto Holden, B.A.Sc., C.E., D.Eng., was a distinguished hydraulic engineer of international reputation. He served Ontario Hydro for 47 years and retired as Chief Engineer in 1960, having been involved in almost all of the major hydro-electric developments in Ontario. On his death Mr. Holden left a sum of money which was later augmented by his widow, the late Florence Holden, to establish a scholarship in the Faculty of Applied Science and Engineering. This scholarship, which has a value of approximately $900 is awarded to the student who, completing the Fourth Year in Civil Engineering or Mechanical Engineering with Honours, obtains the highest aggregate marks in hydraulic engineering subjects in the Third and Fourth Years of the course. The first award was made in the session 1967–68.

ONTARIO STUDENT AWARDS PROGRAM

All students who are attending eligible post-secondary institutions in Ontario may qualify for assistance under this Program provided that they satisfy the residence requirements as outlined in the Ontario Student Awards brochure and demonstrate financial need. An award under this Program will be made to the extent of established need in a combination of a non-repayable grant and a Canadian Student Loan. Application forms and brochures for the 1973–74 Program will be available early in May, 1973. They may be obtained from the University of Toronto, Office of Student Awards, and all other post-secondary institutions. Applications should be submitted *in person* at the institution which the student plans to attend.

THE ONTARIO HOCKEY ASSOCIATION WAR MEMORIAL SCHOLARSHIP

The Ontario Hockey Association War Memorial Scholarship, the gift of the Ontario Hockey Association, is to be awarded annually at the Grade XIII examination to an applicant whose father served overseas with the Canadian Forces in World War I or II.

The value of this scholarship is $100 in cash, with an allowance of the same amount on the tuition fee for each session.

In determining the award of the scholarship, the academic qualifications of the candidate shall be first taken into account, provided always that no candidate shall be eligible for an award who has not met all the conditions required by the University of candidates for admission scholarships generally; but *cæteris paribus*, the award shall be made to a student who is in proved need of assistance.

The award shall be made by the Governing Council of the University upon the report of a committee to be appointed, upon which committee there shall be always one member of the Staff of the University who shall be deemed to be representative of the Association.

Application should be made to the Office of Student Awards on the regular scholarship application form not later than April 19.

PAULIN MEMORIAL SCHOLARSHIP

The Paulin Memorial Scholarship, provided through the generosity of the late Mr. Fred W. Paulin, a graduate of this Faculty in 1907, was established in memory of his brother, John Cameron Paulin, a student of this Faculty, who was fatally injured in 1906 during a football practice. The scholarship, which has the value of the income from a capital fund of $10,000, approximately $550 annually, is awarded to a student who obtains high standing in the work of the first year in the Faculty of Applied Science and Engineering.

PROCTER AND GAMBLE BURSARY PLAN

Procter and Gamble Bursaries, the gift of the Procter and Gamble Company of Canada, are awarded annually to students in all years. Applicants must have at least Second Class Honours or better in the final examinations of the preceding year and demonstrate financial need. Applications must be submitted to the Office of Student Awards on or before December 1.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO ADMISSION SCHOLARSHIP

The Ontario Professional Engineers Foundation for Education provides an admission scholarship of the value of $500. It is awarded to the candidate who obtains the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to the Council that his attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other Admission scholarship.

Application must be made to the Office of Student Awards before April 19.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO SCHOLARSHIPS

The Ontario Professional Engineers Foundation for Education offers scholarships of a value of $250 in each of the First, Second and Third Years in the Faculty of Applied Science and Engineering in any course, to the students who, taking Honours, obtain the highest standing in the work of their respective years.

These scholarships will not be awarded to students who hold other scholarships.

PROFESSIONAL ENGINEERS GOLD MEDAL

The Association of Professional Engineers of the Province of Ontario has established in the Faculty of Applied Science and Engineering an award in the form of a gold medal accompanied by a gift of technical books of an approximate value of $50. The award will be made to the student of the final undergraduate year in any course who, taking honours, obtains the highest weighted average percentage in the practical work and written examinations of the year.

RANSOM SCHOLARSHIP IN CHEMICAL ENGINEERING

The Ransom Scholarship in Chemical Engineering is presented by A. C. Ransom, Esq., of Toronto, for the purpose of encouraging and giving financial assistance to students who choose the field of Chemical Engineering. This donation, consisting of $5,000, provides for a perpetual scholarship of an annual amount such as will be derived from the income of this sum. The first award was made on the results of the annual examinations of 1938.

The scholarship will be awarded annually to the student registered in the Course in Chemical Engineering who obtains the highest aggregate percentage of marks in the examinations of the First Year. The scholarship will be paid to the winner only if he proceeds to take his Second Year in the Course in Chemical Engineering in the University of Toronto.

J. E. REID MEMORIAL PRIZE

This prize, established in 1967 in memory of the late Professor J. E. Reid, is awarded to the student in the Fourth Year of the course in Electrical Engineering who, graduating with honours, achieves the highest aggregate marks in the Fourth Year examinations in the subjects pertaining to electronic communication.

THE RHODES SCHOLARSHIPS

The Rhodes Trustees offer for award in the Province of Ontario two out of ten of the Rhodes Scholarships for Canadians, each of the value of £1,000 and tenable at Oxford University for a period of two years; in certain cases, a third year may be authorized.

Each candidate must be a British subject with at least five years domicile in Canada and unmarried; he must have passed his nineteenth but not twenty-fifth birthday on October 1 of the year *for* which he is elected; he must have completed the first year of his course at a Canadian university at the time of application.

A candidate may apply either for the province in which he has his private home or residence, or for the province in which he has taken his university course.

In that section of the will in which he defined the general type of scholar he desired, Mr. Rhodes mentioned four groups of qualities, the first two of which he considered most important.

(1) Literary and scholastic attainments;
(2) Qualities of manhood, truth, courage, devotion to duty, sympathy, kindliness, unselfishness, and fellowship;
(3) Exhibition of moral force of character and of instincts to lead and to take an interest in his fellows;
(4) Physical vigour, as shown by fondness for and success in outdoor sports.

Some definite quality of distinction, whether in intellect, character or personality, or in any combination of these, is the most important requirement. Financial need does not receive special consideration.

Forms of application and full information regarding these scholarships may be obtained from the Director, Office of Student Awards, University of Toronto, or from Arthur R. A. Scace, Esq., General Secretary for the Rhodes Scholarships in Canada, Box 48, Toronto Dominion Centre, Toronto 1. Selection is made in December for the following year and all applications must reach the provincial secretary before November 15 annually.

R.C.E. MEMORIAL SCHOLARSHIP

The Memorial Fund Committee of the Royal Canadian Engineers has established the R.C.E. Memorial Scholarship of a value of $125, open to students who have successfully completed their second to last year in the Faculty of Applied Science and Engineering or the School of Architecture.

A candidate must be:

(*a*) a member in good standing of the Canadian Officers Training Corps and have successfully completed one summer season's training, or

(*b*) an ex-member of the Canadian Officers Training Corps who has successfully completed two years of C.O.T.C. Training and has transferred to the Canadian Army (Militia) or to the Canadian Army (Supplemental Reserve), or

(*c*) a member of the Canadian Army (Regular) attending University under the Regular Officers Training Plan.

Selection is made on the basis of academic standing and of qualities of leadership.

Application forms may be obtained from the Office of Student Awards.

REGULAR OFFICER TRAINING PLAN

Tenable in approved degree courses, this plan is available to Canadian citizens who undertake to serve in the armed forces for at least four years after graduation. Accepted candidates will receive tuition, a book allowance of $125 and a living allowance of $240 per month during the academic session.

Application should be made to the Canadian Forces Recruiting Centre, 25 St. Clair Avenue West, Toronto 7.

HELEN E. ROGERS ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of Helen E. Rogers open to students entering any degree course in the University. Preference is given to applicants from outside Ontario but failing such candidates awards may be made to qualified Ontario students. Recipients must have a standing satisfactory to the Committee of Award on first admission and may continue to enjoy the scholarship in the upper years provided they maintain first class standing. The value in each year is a minimum of $200 and a maximum of $1,500 dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards by April 19 on the regular admission scholarship application form.

DON SALT MEMORIAL SCHOLARSHIPS

In memory of Donald John Salt, a graduate of the Faculty of Applied Science and Engineering and a practising geophysicist, the Canadian Exploration Geophysical Society has provided two scholarships of the value of $500 which are open to students in the Third and Fourth Years of certain courses in the Faculty of Arts and Science, and in Geological Engineering and the Geophysics option of Engineering Science in the Faculty of Applied Science and Engineering.

The award is made on evidence of the interest and ability of the applicant in relation to the field of mining geophysics.

Application should be made either to the Chairman of the Department of Physics or the Chairman of the Department of Geology by March 1 in the calendar year in which the award is to be made.

ROSEDALE CHAPTER I.O.D.E. AWARD IN ENGINEERING SCIENCE

An award of $400 will be made annually to a student enrolled in the Third Year of the program in Engineering Science, on the basis of academic standing and financial need. Recipients must be Canadian citizens, but not necessarily residents of Ontario.

Application should be made to the Secretary of the Faculty on the regular in-course bursary application form not later than October 15.

FREDERICK W. SCHUMACHER SCHOLARSHIP

The Frederick W. Schumacher Scholarship has been awarded in the Faculty of Applied Science and Engineering and in the Faculty of Arts under a bequest of the late Frederick W. Schumacher. It has a value of the income from the fund. The scholar must (*a*) be enrolled in the Second, Third or Fourth years in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and (*b*) must have high academic standing.

Applications must be submitted to the Office of Student Awards not later than October 15.

"SECOND MILE ENGINEER" AWARD

The Class of 3T5, convinced that a successful engineer must not only be professionally competent but also constantly aware of his responsibilities to humanity, and inspired by an address of President William E. Wickenden of the Case School of Applied Science, Cleveland, called "The Second Mile," which was based on the text from the Sermon on the Mount, "whosoever shall compel thee to go one mile, go with him twain" has established the "Second Mile Engineer" award. It is the desire of the donors to encourage undergraduates to participate fully in extra-curricular activities and to recognize the true importance of the more liberal subjects of the curriculum with the ultimate objective, on entering the profession, of becoming worthy Second Mile Engineers. The award comprises a grant of $200, a suitably inscribed presentation piece and an illuminated scroll, and is presented to a student in his final year.

An eligible group is chosen from those who have taken a prominent part in the affairs of the Faculty, either as office holders or in athletics. In making the award consideration is given to academic standing, with special emphasis on the candidate's attainments in the cultural and humanistic-social studies.

Particulars are furnished each session by the Class of 1935.

THE SIMPSONS-SEARS LIMITED (NORTHERN ONTARIO) SCHOLARSHIPS

These scholarships, the gift of Simpsons-Sears Limited, are open only to students of the Copper Cliff High School, The Sudbury High and Technical Schools, the Sturgeon Falls High School, the North Bay Collegiate Institute and Vocational School, the Kapuskasing High School and all the Secondary Schools along the Ontario Northland Railway. A scholarship of the value of $100 is available for each of the schools mentioned and an additional sum of $50 will be given to the student who obtains the highest percentage of the nine papers of Grade XIII selected in accordance with the regulations.

No scholarship will be awarded unless the candidate is in actual attendance in one of the colleges or faculties of the University and maintains a uniformly high standard to the satisfaction of the donors of the scholarships.

Application for these scholarships must be sent not later than May 15, to the Principal, Algonquin Composite School, North Bay, from whom further information may be obtained regarding conditions of award.

WALLACE AWARD

SOCIETY OF AUTOMOTIVE ENGINEERS PRIZE

In memory of William Wallace, Professor of Mechanical Engineering, University of Toronto, the Ontario Society of Automotive Engineers offers an annual prize of the value of $100 to a student of the Fourth Year in any course whose thesis on a topic related to Automotive Engineering is considered by the Chairman of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory.

SOCIETY OF CHEMICAL INDUSTRY MERIT AWARD

The Society of Chemical Industry Merit Award is made annually by the Society to the student in Fourth Year in the Department of Chemical Engineering who obtains the highest weighted average of marks in the results of the annual examinations for the year. The award is a gold key.

THE MURRAY F. SOUTHCOTE SCHOLARSHIP

Established by friends of the late Murray F. Southcote, a graduate of this Faculty (Aeronautical Engineering, 1950) this scholarship, which has a value of $100, is awarded in recognition of high standing at the Annual Examinations of the Third Year, in any course in the Faculty.

The first award was made in the Session 1964–65.

WALTER STERLING ADMISSION SCHOLARSHIPS

Established in memory of Walter Sterling, these scholarships are open to students entering any first degree course at the University of Toronto. Recipients must obtain First Class Honours standing on the Ontario Grade XIII papers required for admission, and may continue to enjoy the scholarships in each year of their course providing they maintain Honour standing. The value of the scholarship is from $200 to $1,500 annually, dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards on the regular scholarship application form. The statement of financial need should be completed if an award greater than $200 is desired.

C.H.E. STEWART BURSARIES

Under the provisions of the will of the late Mary Jones Stewart a sum of $10,000 was bequested to the University, the income of which is to be used to provide a number of bursaries in denominations of $50, $75 and $100 to students in the Third and Fourth Years of courses in the Faculty of Applied Science and Engineering, the awards to be made on the basis of financial need, scholastic ability and general character, with preference being given to students who are descendants of veterans of the First and Second World War. Applications should be submitted to the Secretary of the Faculty by October 15, on the regular in-course bursary application form.

EDITH TYRRELL MEMORIAL BURSARY

The Women's Association of the Mining Industry of Canada has presented this Bursary, having the value of $600, annually, commencing in 1939, and named in memory of their founder and first president, Mrs. Edith Tyrrell. A medal donated by Dr. Tyrrell accompanies this Bursary. The Bursary is awarded to a student entering the Third or Fourth Year in the Course of Metallurgy and Materials Science, or Geological Engineering; it may be awarded two years in succession to the same student, but will usually be awarded at the beginning of the Third Year. The award will be made by a special committee appointed by the Association on the following basis:

(*a*) In addition to mental capacity, the student must show leadership ability and give promise, through his activities, of becoming a worthwhile influence in the affairs of the profession and the community.

(*b*) While attention is given to scholastic ability, as evidenced by his academic standing, it is not the governing factor. He must, however, stand in the top quarter of his class.

(*c*) Special consideration is given to financial need.

Application must be made to the Secretary of the Faculty within one month of the opening of the academic year.

S. UBUKATA FUND

The S. Ubukata Fund for Japanese students was established to assist students from Japan proper to pursue a course of study at the University of Toronto. The fund provides grants of varying values on the basis of the information submitted by the applicants who:

(*a*) must be Japanese students from Japan proper;
(*b*) must register in the University of Toronto devoting full time to their studies;
(*c*) are able to satisfy admission requirements regarding English facility;
(*d*) are not holding other financial aid.

UNIVERSITY OF TORONTO ALUMNI ASSOCIATION WAR MEMORIAL SCHOLARSHIPS

Six scholarships are awarded annually by the University of Toronto Alumni Association to students entering first degree courses at the University of Toronto. The scholarships have a value of $500 annually, and are tenable for two years, providing satisfactory academic standing is maintained. They are awarded for general proficiency in Grade XIII, and in addition to academic performance the committee of award will take into consideration the candidate's relationship to active service in the Armed Forces of Canada, need of financial assistance, participation in extra-curricular activities and such other qualifications as may commend themselves to the committee. One scholarship will be available to a student whose home is not in the Province of Ontario.

Students resident in Ontario may apply on the general admission scholarship form which must be submitted to the Office of Student Awards not later than May 1. Evidence of relationship to active service in the Armed Forces of Canada should be attached. Students resident outside Ontario may obtain the necessary forms from the Office of Student Awards, University of Toronto.

THE U.T.S. ENGINEERING SCHOLARSHIP

The U.T.S. Engineering Scholarship, the gift of R.A. Bryce, Esq., of the value of $250. The scholarship will be awarded by a committee of the Staff of the University of Toronto Schools to a student of the Schools who has completed the requirements for admission to and enrols in the Faculty of Applied Science and Engineering.

WALLBERG ADMISSION SCHOLARSHIPS

Six admission scholarships, each of a value of $1000 are awarded annually from the income from the Wallberg Bequest on the recommendation of the Council of the Faculty to the six candidates who obtain the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to Council that this attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other Admission scholarship.

Applications must be submitted to the Office of Student Awards on the prescribed form by April 19.

WALLBERG UNDERGRADUATE SCHOLARSHIPS

These scholarships, four in number, of the value of $500 each, derived from the Wallberg Bequest, are awarded annually; two to students ranking first and second respectively at the annual examinations of the First Year; one to the student ranking first at the annual examinations of the Second Year; and one to the student ranking first at the annual examinations of the Third Year.

Any holder of one of these scholarships may not hold other awards listed in the index with an asterisk. The awards were first made on the result of the annual examination of 1947.

W. S. WILSON MEDALS

These medals have been provided in recognition of the service to the Faculty of Applied Science and Engineering of its former Assistant Dean and Secretary, William Stewart Wilson.

A medal will be awarded to the student in each graduating course, who, attaining Honours, achieves the highest standing in the final year of his course.

The first awards were made in the Session 1962–63.

WILLIAM R. WORTHINGTON MEMORIAL SCHOLARSHIP

The William R. Worthington Memorial Scholarship, the gift of Miss Ida R. Worthington, in memory of her brother, William R. Worthington, DIP.(1904, B.A.SC.(1905), of the value of the income from a fund is awarded annually to the student of the Second Year in the course in Civil Engineering who ranks highest at the annual examinations of that year.

The first award was made at the examination for the Session 1954–55.

LOAN FUNDS

From the loan funds mentioned below, small loans can be made to students who are in urgent need of assistance. The funds are not large and the loans must accordingly be restricted, both in amount and number, and principally to students in the Third and Fourth Years.

Inquiries for loans from any of the following funds should be made at the office of the Secretary of the Faculty.

Engineering Society Loan Fund
Elizabeth Speller Memorial Fund
James W. Crocker Memorial Fund
Harry F. Bennett Educational Fund
S.A.E. – Canadian Section Loan Fund
Avro Aircraft Limited Engineering Loan Fund
The William Storrie Memorial Fund
3T6 Engineers Loan Association
4T0 Engineering Loan Fund
The Devonshire Loan Fund
Class of '09 Trust Fund
University of Toronto Alumni Loan Fund
Wallberg Memorial Loan Fund

CLASS OF 1936 LOAN ASSOCIATION

Members of the Class of 1936 have made arrangements to assist students in obtaining loans through regular banking facilities. Information may be obtained from the Secretary of the Faculty.

ENGINEERING SOCIETY LOAN FUND

In 1932 the Engineering Society repaid to the Board of Governors a series of annual grants which, over a period of years, had been made to the Society for special purposes. The Board of Governors, appreciating this action, set aside this sum, to be known as the Engineering Society Loan Fund, to provide loans to students of the Faculty of Applied Science and Engineering. The administration of the fund is carried out by a Committee appointed by the Governing Council. The fund is not large, and only small loans can be made to relatively few students. Further inquiries should be made at the office of the Secretary of the Faculty.

ELIZABETH SPELLER MEMORIAL FUND

Through the generosity of Dr. F. N. Speller, of the Class of 1893, the "Elizabeth Speller Memorial Fund" has been established to provide loans for worthy students of the Third and Fourth Years of this Faculty. Applications for loans from this Fund should be made to the Secretary of the Faculty.

JAMES W. CROCKER MEMORIAL LOAN FUND

This fund was established by Mrs. William Crocker in memory of her son, James W. Crocker, a graduate in Mining Engineering in 1938, who was killed in an accident in a mine in the same year.

HARRY F. BENNETT EDUCATIONAL FUND

This fund was established by subscription from members of The Engineering Institute of Canada in memory of the late Harry F. Bennett, M.E.I.C., who for six years prior to his death in 1946 was chairman of the Institute's Committee on the Training and Welfare of the Young Engineer, and who accomplished so much in this field by untiring efforts.

One purpose of the fund is to make loans to deserving students who need financial assistance to enable them to study engineering sciences at university level, and who have proved themselves by successfully completing their first year in engineering or the equivalent.

Loans will be made largely on the basis of character and to men who seem likely to develop the high professional standards which are essential to leadership in engineering science. A student who has been aided by this fund should feel that high obligations are placed on him; obligations to the subscribers, to the trustees, and to those coming after him who in turn can receive help as his loan is repaid.

Application forms may be obtained at the Faculty Office. The regulations are simple and the application of any worthwhile student will be given immediate and careful attention.

SOCIETY OF AUTOMOTIVE ENGINEERS – CANADIAN SECTION LOAN FUND

The Society of Automotive Engineers – Canadian Section has established a loan fund of $1,200 in the Faculty of Applied Science and Engineering. Preference is given to students in good scholastic standing and engaged in studies relative to the automotive and aircraft industries, and to students in fourth, third and second years in that order. Particulars may be obtained from the Secretary of the Faculty.

AVRO AIRCRAFT LIMITED ENGINEERING LOAN FUND

Avro Aircraft Limited has established a Loan Fund of $3,000 to provide loans to engineering students requiring financial assistance. Application should be made to the Secretary of the Faculty.

THE WILLIAM STORRIE MEMORIAL FUND

The William Storrie Memorial Fund has been established by Mrs. William Storrie to provide loans to undergraduates in the course in Civil Engineering. Application should be made to the Secretary of the Faculty.

THE DEVONSHIRE LOAN FUND

This fund has been established by Graduates and friends of Devonshire House to assist students in the Residence. Application should be made to the Office of the Dean of Devonshire House.

CLASS OF '09 TRUST FUND

The Class of '09 on the 50th Anniversary of their graduation made a sum of money available in the Faculty for financial aid to undergraduates, with preference to Second Year students. Inquiry should be made to the Secretary of the Faculty.

THE UNIVERSITY OF TORONTO ALUMNI LOAN FUND

This fund comes from subscriptions received originally in 1919 and in succeeding years from graduates of the University and is administered by the University of Toronto Alumni Association.

Loans are available to undergraduate and graduate students enrolled in a full time course at the University, in second and subsequent years.

Particulars may be obtained from The University of Toronto Alumni Association, Alumni House, Willcocks Street, Toronto.

IX Discipline

A SUMMARY OF THE REGULATIONS OF THE CAPUT CONCERNING STUDENT DISCIPLINE*

1. Subject to the general regulations of the Caput of the University regarding jurisdiction in matters of discipline the Council of University College, the governing bodies of the Federated Universities and Affiliated Colleges, and the Councils of the Faculties, Schools, and Institutions have disciplinary jurisdiction over the conduct of all students registered in these Divisions of the University in all matters of local or internal concern to these Divisions. Jurisdiction over the conduct of students while in residence regardless of the Division of the University in which they are registered is vested in the body administering the residence.

2. Jurisdiction concerning conduct likely to affect the interests of the University as a whole is vested in the Caput.

3. The Students Administrative Council will be supported in the proper performance of all its obligations and duties as provided in its Constitution.

4. Where the appropriate body exercising disciplinary jurisdiction has found that a student of the University has engaged in conduct prejudicial to the interests of the University, the Caput may, in its discretion, suspend or expel such student from the academic privileges of the University. Every decision of the Caput involving the expulsion of a student from the University requires confirmation of the Governing Council.

5. Any student who interferes with the personal liberty of another or who subjects another student to indignity or personal violence may be considered by the Caput or any other body exercising disciplinary jurisdiction in the University to have committed a breach of discipline.

6. Initiation ceremonies involving physical violence, personal indignity, interference

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*As of 1972/73. A committee of the Governing Council began in the fall of 1972 to examine the whole question of discipline at the University of Toronto, and it is expected that a new or significantly amended set of disciplinary structures and principles will be introduced in the session 1973/74. Inquiries should be directed to the Secretary of the Faculty or to the Office of the Vice-President – Internal Affairs, Simcoe Hall.

with personal liberty, or destruction of property, may be deemed a breach of discipline by the Caput or any other body exercising disciplinary jurisdiction in the University.

7. Without limiting the disciplinary powers vested in the respective bodies exercising disciplinary jurisdiction as set forth in sections 1–7, the following are cited as illustrations of conduct which, in the past, has been considered a breach of discipline prejudicial to the interests of the University:

(i) The organising of a parade on the streets of the city or the taking part in such a parade without permission of the authorities.

(ii) The destruction or defacing of University property, raids on Residences or other University buildings, and the breaking into University buildngs.

(iii) Rowdy and other forms of behaviour, either on or off the Campus, of such an objectionable nature as to bring the University into public disrepute.

8. Student Clubs and Associations

(a) The constitution of every society or association of students in the University and all amendments to such constitutions require to be approved by the relevant University authorities. The giving of approval, and the responsibility for the programs of student societies and associations, shall rest as follows:

(i) With the authorities of the College, Faculty or School concerned where the membership of the student society or association is drawn from a single College, Faculty or School.

(ii) With the Board of Stewards of Hart House, where the student society or association is a Committee of Hart House and is controlled by the Board of Stewards of Hart House.

(iii) With the Caput, in the case of all other student societies and associations.

(b) No approval will be given by any of the authorities listed in (a) above to the constitution of any society or association of students if that constitution permits:

(i) Membership in the society or association to persons who are not students of the University, unless in the case of the societies listed in (a) (ii) above, where membership is open also to graduates of the University and members of the Faculty of the University.

(ii) Any action of discrimination based upon race, religion, or colour.

9. The name of the University is not to be used in connection with a publication of any kind without permission of the Caput.

X Professors Emeriti

PROFESSORES EMERITI

E. A. Allcut, M.SC. (BIRM.), M.E., F.R.A.E.S.,
Professor Emeritus of Mechanical Engineering

J. G. Breckenridge, B.A.SC., PH.D. (CAMB.),
Professor Emeritus of Chemical Engineering and Applied Chemistry

W. B. Dunbar, B.A.SC.,
Professor Emeritus of Engineering Drawing

C. E. Helwig, M.A.SC.,
Professor Emeritus of Civil Engineering

P. B. Hughes, B.SC. (MCG.), D.ENG. (EMBRY RIDDLE),
Professor Emeritus of Mechanical Engineering

K. B. Jackson, B.A.SC., D.SC. (WATERLOO),
Professor Emeritus of Applied Physics

G. R. Lord, B.A.SC., S.M. (M.I.T.), PH.D.,
Professor Emeritus of Mechanical Engineering

O. J. Marshall B.A.SC., C.E., O.L.S.,
Professor Emeritus of Civil Engineering

W. G. McIntosh, B.A.SC.,
Professor Emeritus of Mechanical Engineering

J. W. Melson, B.A.SC.,
Professor Emeritus of Surveying and Geodesy

C. F. Morrison, B.E. (SASK.), M.SC. (MCG.),
Professor Emeritus of Civil Engineering

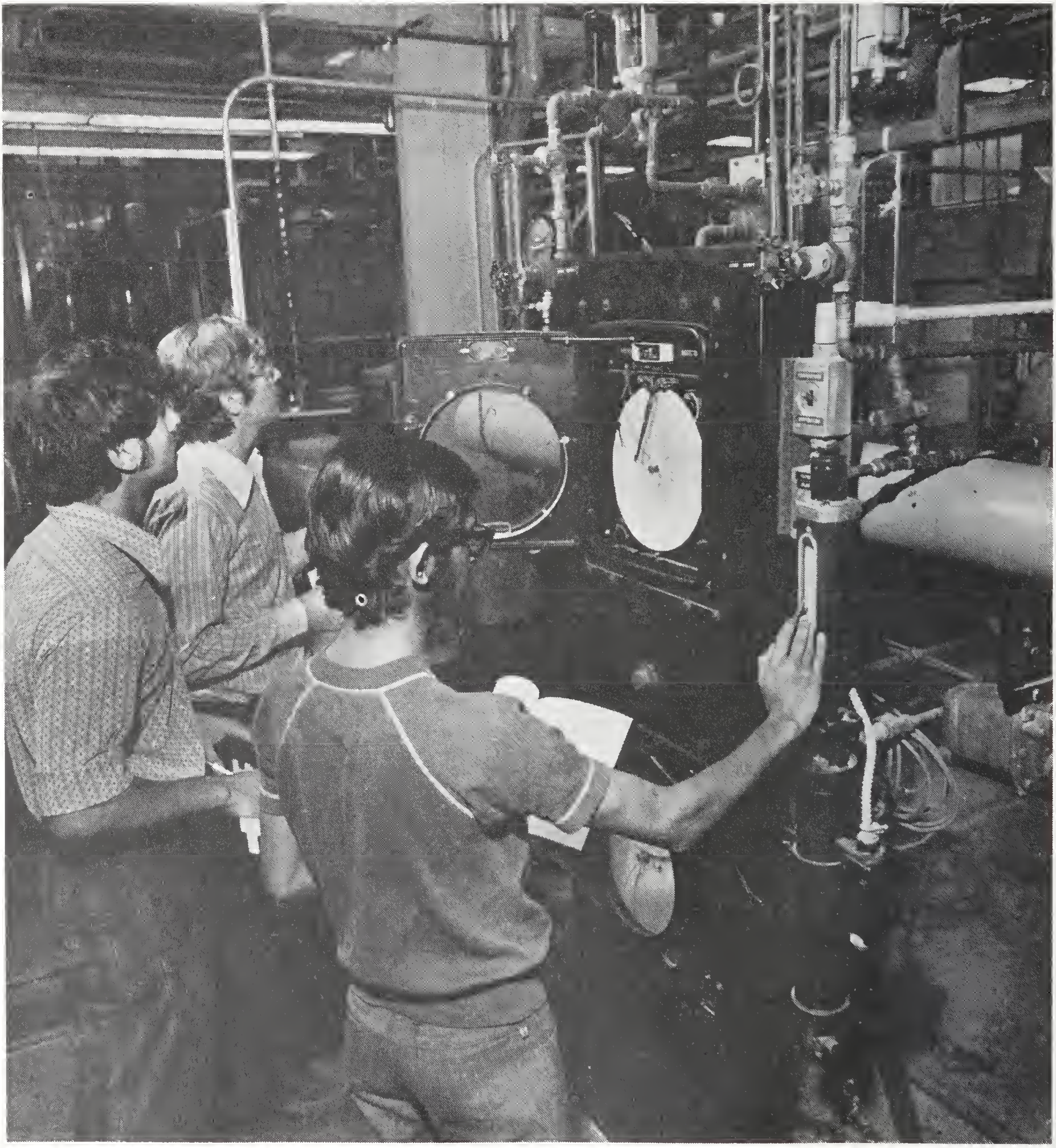
L. M. Pidgeon, M.B.E., B.SC. (OXON.), PH.D. (MCG.), F.R.S.C.,
Professor Emeritus of Metallurgy and Materials Science

E. A. Smith, M.A.(MCM.),
Professor Emeritus of Chemical Engineering

G. F. Tracy, B.A.SC., S.M.(M.I.T.),
Professor Emeritus of Electrical Engineering

A. Wardell, B.A.SC.,
Professor Emeritus of Engineering Drawing

W. J. T. Wright, M.B.E., B.A.SC., B.A.,
Professor Emeritus of Engineering Drawing



XI

Administrative Officers

1972–73

THE UNIVERSITY

President: J. R. Evans, M.D., D.PHIL., F.R.C.P.(C.), LL.D.
Assistant to the President: N. S. C. Dickinson, C.D., B.A.
Vice-President and Provost: D. F. Forster, B.A., A.M.
Vice-Provost, Research Administration: Miss S. Dymond, B.A., Q.C.
Vice-Provost: J. D. Hamilton, M.D., F.R.C.P.(C.), D.SC.
Vice-Provost: P. P. M. Meincke, B.SC., M.A., PH.D.
Vice-Provost: R. Ross, M.B.E., M.A.
Vice-President, Institutional Relations and Planning: J. H. Sword, M.A., LL.D.
Vice-President, Business Affairs: A. G. Rankin, B.COM., F.C.A.
Assistant Vice-President: F. R. Stone, B.COM., F.C.A.
Secretary to the Governing Council: D. S. Claringbold

Chief Librarian: R. H. Blackburn, M.A., B.L.S., M.S., LL.D.
Acting Director of University Extension: E. M. Gruetzner, B.A.
Director of Admissions: W. Kent, M.A.
Director of Statistics and Records: J. M. Tusiewicz, B.SC.(ENG.), M.A.SC., M.B.A.
Director of Student Awards: P. S. Phillips, B.A., C.A.

Director of Finance, M. E. Dedrick, B.COM., M.COM.
Director of Physical Plant: J. T. Turner, B.SC., P.ENG.
Director, Special Projects: G. P. Hiebert, B.COM., C.A.
Director of Personnel: R. F. Brown
Director of Administrative Services: M. A. Malcolm, B.A.
Director of Information Systems Department: V. H. Mikkelson

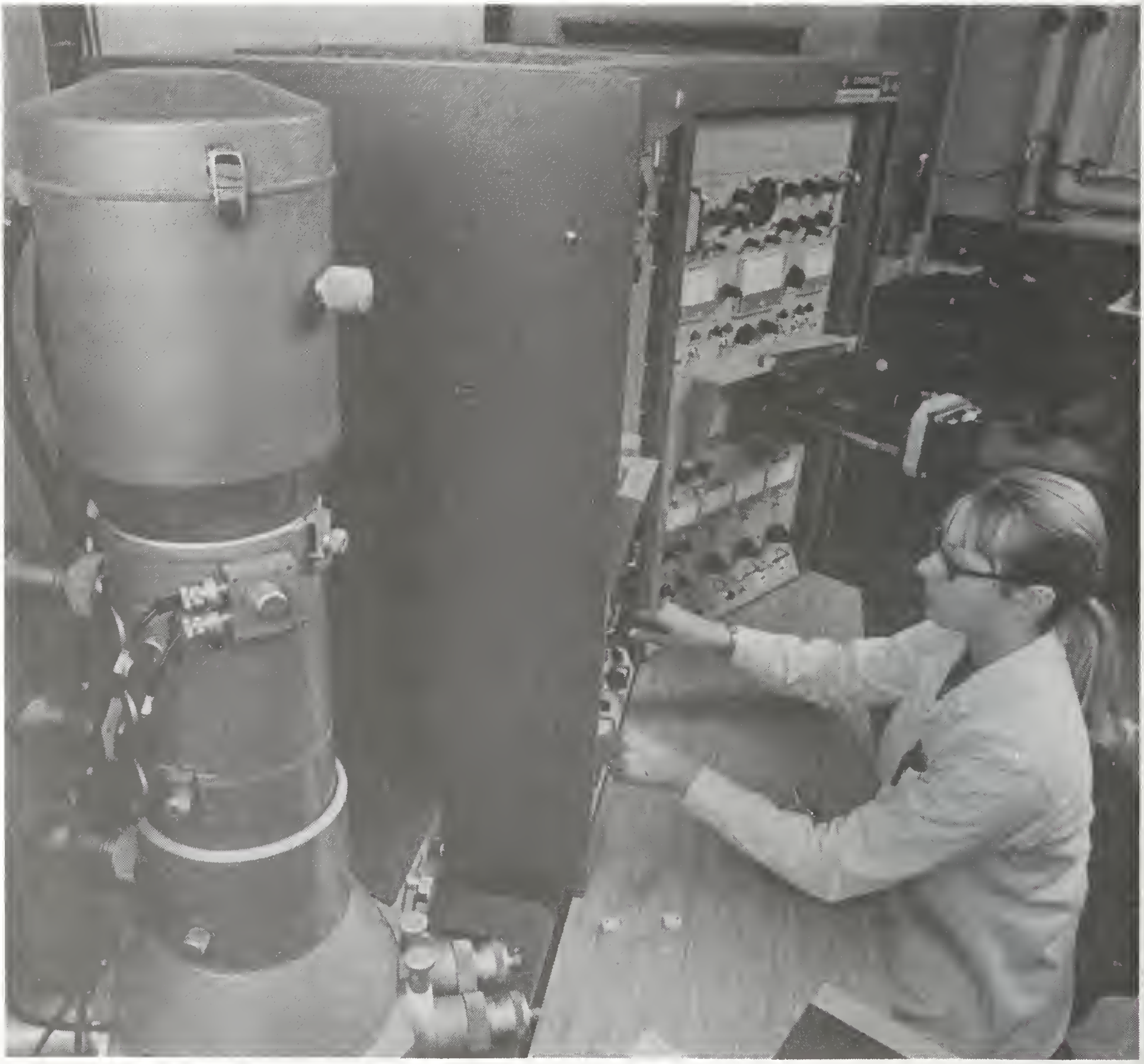
Co-ordinator Campus Services: Miss H. L. Reimer, B.A., B.PED.
Director of the Advisory Bureau: D. J. McCulloch, B.A., M.D., D.PSYCH., F.R.C.P.(C.)

Director of Athletics and Recreation (Men): A. D. White, B.A., M.ED.
Director of Physical and Health Education (Women): Miss A. Hewett, B.ED., P.E.
Director of Career Counselling and Placement Centre: D. Currey, B.A.SC.
Director of University Health Service:
G. E. Wodehouse, M.C., M.D., F.R.C.P.(C.), M.R.C.P.
Director of Housing Service: Mrs. M. G. Jaffary, B.A.
Director of the International Student Centre: E. A. McKee, M.A.

Warden of Hart House: J. G. Lengellé, M.A., PH.D.

Director of the University of Toronto Press: M. Jeanneret, B.A., LL.D.

Director of the University News Bureau: K. S. Edey
Director of Alumni Affairs: J. W. Duncanson, B.A.
Director of Development: R. L. Jones



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The University of Toronto issues the following calendars and other publications concerning courses of instruction given by the University. Requests for calendars or information may be directed to the Office of Admissions of the University or to the Secretary of the particular Faculty, School or Institute.

ADMISSION INFORMATION:	Admission Awards Undergraduate Admission Handbook Undergraduate Admission Bulletin
APPLIED SCIENCE AND ENGINEERING:	Faculty of Applied Science and Engineering Engineering at Toronto – descriptive brochure
ARCHITECTURE:	Faculty of Architecture, Urban and Regional Planning and Landscape Architecture
ARTS AND SCIENCE:	Faculty of Arts and Science – St. George Campus Scarborough College Calendar Erindale College Calendar
CHILD STUDY:	Institute of Child Study, Faculty of Education
DENTISTRY:	Faculty of Dentistry Division of Postgraduate Dental Education Division of Dental Hygiene
EDUCATION:	Faculty of Education Bachelor of Education in Extension Graduate Degrees in Education*
EXTENSION:	Degree Programmes in Extension Diploma and Certificate Programs in Extension Pre-University Courses Continuing Education Program (Special Programs)
FOOD SCIENCES:	Faculty of Food Sciences
FORESTRY:	Faculty of Forestry
GRADUATE STUDIES:	School of Graduate Studies
HYGIENE:	School of Hygiene
LAW:	Faculty of Law
LIBRARY SCIENCE:	Faculty of Library Science
MANAGEMENT STUDIES:	Faculty of Management Studies
MEDICINE:	Faculty of Medicine, Medical Course Department of Rehabilitation Medicine Division of Postgraduate Medical Education
MUSIC:	Faculty of Music Royal Conservatory of Music Year Book
NURSING:	Faculty of Nursing
PHARMACY:	Faculty of Pharmacy
PHYSICAL AND HEALTH EDUCATION:	School of Physical and Health Education
SOCIAL WORK:	Faculty of Social Work

*Write to: Ontario Institute for Studies in Education, 252 Bloor Street West, Toronto, Ontario, M5S 1V6.

University
of Toronto

Faculty of
Applied Science
and Engineering

Calendar 1974-1975

University of Toronto Press
1974

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CALENDAR 1974

January

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CALENDAR 1975

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I

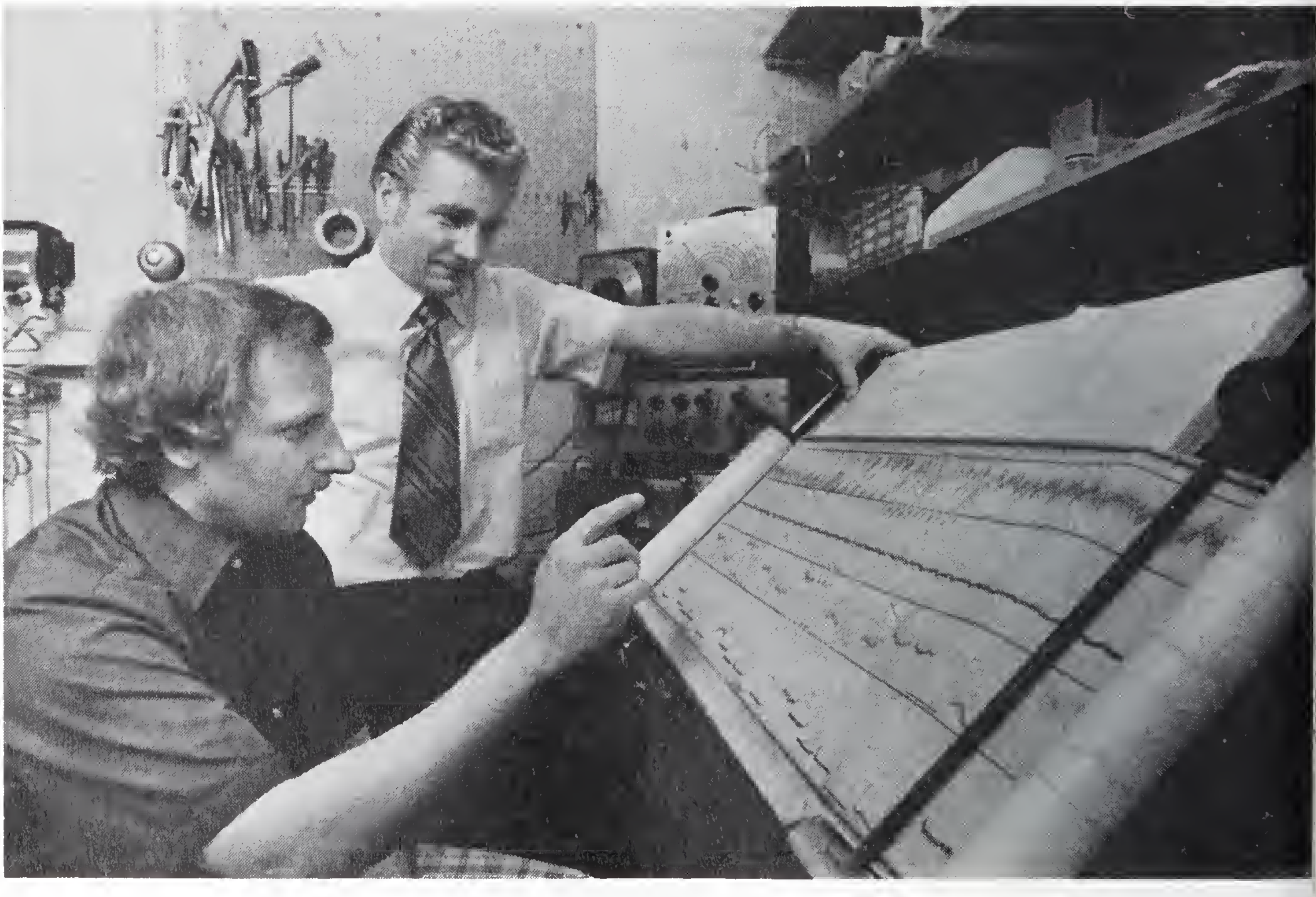
Calendar 1974-1975

FALL TERM, 1974

August 28	Wednesday	*Registration of First Year Students, from 9:30 a.m. to 12:00 (surnames A to L), 2:00 p.m. to 4:30 p.m. (surnames M to Z)
August 29	Thursday	*Registration of Second Year students, from 9:30 a.m. to 12:00 noon *Registration of Third Year students, from 2:00 p.m. to 4:30 p.m.
August 30	Friday	*Registration of Fourth Year students, from 9:30 a.m. to 12:00 noon *Students residing outside Metropolitan Toronto may register on Tuesday, September 3, 1974, without penalty.
September 2	Monday	Labour Day. Buildings closed.
September 3	Tuesday	Orientation program for First Year students.
September 4	Wednesday	Lectures and laboratory work commence at 9:00 a.m.
September 20	Friday	Last day for students to add or substitute courses (including Fall Term courses taken in the Faculty of Arts and Science).
October 4	Friday	Last day for students to add or substitute a Full Year course taken in the Faculty of Arts and Science.
October 14	Monday	Thanksgiving Day. Buildings closed.
October 18	Friday	Last day for students to drop a course without academic penalty (including Fall Term and Full Year courses taken in the Faculty of Arts and Science).
October 31	Thursday	Meeting of Faculty Council.
November 8	Friday	Last date for withdrawal from the Fall Term without academic penalty.
December 6	Friday	Last day of lectures in Fall Term. All term work should be submitted by this date.
December 9 to December 20	Monday Friday	Study and examinations in Fall Term courses.
December 25	Wednesday	Christmas Day. Buildings closed.

SPRING TERM, 1975

January 1	Wednesday	New Year's Day. Buildings closed.
January 6	Monday	Lectures and Laboratory work commence at 9:00 a.m.
January 17	Friday	Last day for students to add or substitute Spring Term courses (including Spring Term courses taken in the Faculty of Arts and Science).
January 29	Wednesday	Meeting of Faculty Council.
February 17	Monday	Faculty holiday. Lectures and laboratories withdrawn.
February 21	Friday	Last day for students to drop a Spring Term course without academic penalty (including Spring Term courses taken in The Faculty of Arts and Science).
March 14	Friday	Last date for students to withdraw from the Spring Term without academic penalty.
March 28	Friday	Good Friday. Buildings closed.
April 11	Friday	Last day of lectures in Spring Term. All term work should b submitted by this date.
April 14 to April 25	Monday Friday	Study and examinations in Spring Term courses.
May 26	Monday	Meeting of Faculty Council.



II

The Faculty of Applied Science and Engineering

ADMINISTRATIVE STAFF

Dean: B. Etkin, B.A.SC., M.A.SC., D.ENG., F.R.S.C.
Associate Deans: P. I. P. Boulton, B.A.SC., M.A.S.C., PH.D.
G. B. Craig, B.A.SC., M.A.SC., PH.D.
Executive Assistant and Secondary School Liaison Officer:
J. S. Hewitt, B.SC.(QU.), M.SC., PH.D.(BIRM.)
Assistant Dean and Secretary: J. A. Gow, B.A.SC.

The Faculty of Applied Science and Engineering in the University of Toronto offers the widest range of undergraduate and post-graduate studies in engineering in Canada. Students may qualify for the Bachelor of Applied Science Degree (B.A.Sc.) in any one of eight programs: Civil Engineering; Geological Engineering and Applied Earth Science; Mechanical Engineering; Industrial Engineering; Engineering Science; Chemical Engineering; Electrical Engineering; Metallurgy and Materials Science. Within these programs there are many electives and options. In the Geological Engineering program, students can specialize in Mineral Exploration, Mineral Engineering or Geotechnical Engineering. In the Engineering Science program, students can in their final two years take one of the options: Aerospace; Chemical; Computer Science; Electrical; Geophysics; Materials Science; Nuclear and Thermal Power; Physics. Thus, an engineering student can specialize in virtually any significant branch of modern technology. Admission standards and the First Year curriculum are common to all programs except Engineering Science. Admission to the latter is restricted to High School graduates with substantially better than minimum qualifications, and the First Year curriculum in that program is more demanding both in level and in pace.

The bulk of the teaching of undergraduate students in engineering is provided by the six departments of the Faculty (which altogether comprise about 180 professors): Civil Engineering, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Electrical Engineering, Metallurgy and Materials Science. Additionally, undergraduate teaching is provided by the Institute for Aerospace Studies (an Institute of this Faculty) and the Institute of Biomedical Engineering (an Institute in both this Faculty and the Faculty of Medicine).

The Faculty is most fortunate in being part of a great university, and consequently has available to it the resources of other Divisions, upon which it draws to great advantage. The Departments of Geology, Mathematics, Physics, English, History, Philosophy, and Political Economy, all in the Faculty of Arts and Science, make contributions to the engineering curriculum which greatly enrich it.

Beyond the undergraduate level, the Faculty has a strong commitment to graduate studies and research. Graduate programs leading to the M.Eng., M.A.Sc., and Ph.D. degrees are offered through the School of Graduate Studies by each of the six departments and two institutes previously mentioned. The staff of the Faculty also contributes at the graduate level to the programs of several other centres and institutes in the areas of urban planning, transportation, environmental studies and history of technology. This remarkable pattern of bridges linking the Arts, Sciences and professions in studies of man, his ideas and his work, lends a distinctive vitality and range to engineering at Toronto.

Since its founding in 1873, the School of Practical Science at the University of Toronto, which became the Faculty of Applied Science and Engineering in 1906, has conferred more than 18,000 degrees and diplomas. Of the 16,000 living graduates, 6,300 reside in Metropolitan Toronto, a further 5,700 in other communities throughout Ontario and 2,000 in other provinces in Canada. Another 1,500 are living in the United States and more than 500 in other areas of the world, including Africa, Asia, Europe, South America, Central America and Mexico, Oceania and the West Indies.

These graduates have pursued diverse carreers in all fields of engineering: in the resource industries, manufacturing, transportation, communications: in law, finance and health care systems. They are employed by governments from the municipal to the federal level, in private enterprise, both large and small, and throughout our educational system.

Currently there are some 2,300 undergraduate and 550 postgraduate students. An important historical point for students is that the Engineering Society, with its "Cannon" and "LGMB" is the oldest engineering organization of any formal kind in Canada.

The Faculty is located on the main campus in a rectangle bounded on the south by College Street, the west by St. George Street, the north by Convocation Hall and on the east by Taddle Creek Road where in the days of Canadian Confederation there was indeed a creek so named.

The administrative offices are located in the southwest corner of the Galbraith Building at 35 St. George Street. Students and visitors may obtain information and assistance here.

SUMMARY OF STUDENTS IN ATTENDANCE – *Session 1973–74*

PROGRAM		1	2	3	4	5	6	7	8	TOTAL
Year	I	128	17	103	47	167	105	138	10	715
	II	121	27	88	49	76	49	103	12	525
	III	119	36	97	66	87	53	84	16	558
	IV	74	32	96	65	63	61	79	18	488
TOTAL										2286
Special Students										13

III

General Information Admission and Registration

ADMISSION REQUIREMENTS

1. Full details of the University of Toronto undergraduate admission requirements for 1975 are contained in the Undergraduate Admission Handbook 1975–76 available on request from the Office of Admissions, University of Toronto, Toronto, Ontario, Canada, M5S 1A3 and in all Ontario secondary schools. The 1974 requirements follow.

2. ONTARIO GRADE 13 GENERAL REQUIREMENTS:

Entrance to the First Year of the undergraduate courses is offered, depending upon the number of places available, to candidates from Ontario secondary schools who demonstrate good standing, based upon the following evidence:

1. Completion of secondary school studies, including a full program of academic work at the Grade 13 level.
2. A recommendation by the secondary school last attended regarding probable success in university studies.
3. A complete academic report for the last three years of secondary school.

The Grade 13 program should include Relations and Functions, Algebra, Calculus, Physics and Chemistry. Superior students, who have completed a full Grade 13, but whose programs do not include all of these subjects will also be considered. When admissibility is not clear, consideration will be given to evidence of motivation and of ability with language.

In addition, candidates seeking admission to the program in Engineering Science should have excellent standing.

NOTE: The University of Toronto does not require applicants for admission to submit the results of standardized tests offered by the Service for Admission to College and University (SACU). However, individual applicants may, if they so wish, present SACU test scores as additional evidence of their academic aptitude. Such information will be considered by admission and scholarship committees on an individual basis.

3. APPLICATION PROCEDURES

Candidates currently in Ontario Grade 13 should apply through their high school using the General Application Form.

All other candidates should write to the Office of Admissions for a questionnaire which they will be invited to fill out for preliminary consideration.

The closing date for the receipt of applications is June 1. Only in circumstances which the Committee on Admissions deems exceptional will a late application be considered.

4. CANDIDATES OFFERING CERTIFICATES OTHER THAN ONTARIO GRADE 13:

The following certificates are usually accepted as equivalent to Ontario Grade 13 although individual subjects cannot always be equated. The candidates must offer from their final secondary school year, a full Senior Matriculation program including mathematics, physics and chemistry.

Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Saskatchewan — Grade 12
Newfoundland — First Year Memorial University
Prince Edward Island — First Year University of Prince Edward Island
Quebec — C.E.G.E.P. I or equivalent

The following are also usually accepted as equivalent to Ontario Grade 13 although individual subjects cannot always be equated. Candidates applying for admission to the Faculty of Applied Science and Engineering should include mathematics, physics and chemistry in their studies.

UNITED STATES, CENTRAL AND SOUTH AMERICA

First Year University standing (normally 30 semester hours) in acceptable subjects from an accredited institution. Excellent students with high school diploma and C.E.E.B. Advanced Placement Examinations will be considered.

ENGLAND, WEST INDIES, EAST AND WEST AFRICA, HONG KONG

General Certificate of Education, Higher School Certificate or University of Hong Kong Matriculation Certificate showing either passes in five subjects of which at least two must be passed at advanced (or principal) level; or passes in four subjects of which at least three must be passed at advanced (or principal) level. In either case passes are required in physics, chemistry and an acceptable mathematics subject. At least two of these must be at advanced level.

EUROPE AND COMMONWEALTH

A Graduation (Maturity) certificate from the final year of secondary school is required from most European and Commonwealth countries.

INDIA, PAKISTAN

Bachelor's degree with high standing.

JAPAN, KOREA, TAIWAN

First Year University standing in acceptable subjects from an accredited institution.

PHILIPPINES

Second Year University standing in acceptable subjects from an accredited institution.

5. STANDARDIZED TESTS

Candidates from educational jurisdictions outside Ontario may improve their competitive position by taking the aptitude and applicable achievement tests offered by the Service for Admission to College and University or the aptitude test offered by the College Entrance Examination Board. For information they should write to the Service for Admission to College and University, 151 Slater Street, Ottawa, Ontario, Canada, K1P 5N1, or to the College Entrance Examination Board, Box 592, Princeton, New Jersey 08540, U.S.A.

6. ENGLISH FACILITY

In addition to meeting the academic requirements outlined above, candidates whose mother tongue is not English may be required to meet an appropriate standard in a recognized test of English facility such as the University of Michigan English Language Test, the Certificate of Proficiency in English issued by the Universities of Cambridge or Michigan, or the Test of English as a Foreign Language (T.O.E.F.L.). The University of Toronto is a sponsoring agency for the University of Michigan English Language Test and information about the test is sent to any applicant of whom it will be required.

7. NON-MATRICULANTS (MATURE STUDENTS)

For information regarding admission as a Non-Matriculant (Mature Student), please consult the Office of Admissions.

8. EARLY ADMISSION

(Ontario Grade 13 students only)

Ontario Grade 13 students with good school records may be offered admission as early as May 31, 1974.

Students wishing to be considered for Early Admission should ensure that their applications are forwarded by their schools to the Ontario Universities' Application Centre not later than December 31, 1973.

9. CANDIDATES WHO HAVE PREVIOUSLY FAILED IN UNIVERSITY WORK

Candidates with a previous failure in university work may be considered individually on their merits; candidates with two previous failures are normally refused admission.

10. PROCEDURE FOR REGISTRATION

Detailed instructions concerning registration will be mailed to returning and newly admitted students before the beginning of each academic year.

11. UNIVERSITY HEALTH SERVICE

The University Health Service operates a medical clinic at 256 Huron Street, a psychiatric consultation service at 2 Bancroft Avenue, an infirmary service at 42 St. George Street and an athletic injury surgery in Hart House.

All students are urged to obtain medical and hospital insurance coverage through the Ontario Health Insurance Plan (OHIP).

COLLEGES

New College and Innis College are multi-faculty colleges established within the University of Toronto. It is possible, but not obligatory, for students of the Faculty of Applied Science and Engineering to become members of these colleges. Application for membership is at the option of the student.

Students entering the First Year who are interested in becoming members of either college should indicate their choice in the space provided on the University's admission application form. A college fee of $15 for New College, $17 for Innis College is required upon acceptance.

The facilities of Innis College and New College are described below.

INNIS COLLEGE

Innis College was constituted on July 1, 1964, and admitted its first students in the following September. It is a multi-faculty college of the University of Toronto, and includes undergraduate students in all Faculties and Schools of the University.

A special feature is the Writing Laboratory. This service offers assistance to Innis College students in the skills and methods of writing essays and other academic reports. A staff of experienced teachers is available to give individual instruction.

The College has limited residential space available in houses on campus. Separate application for residence accommodation must be made directly to the Residence Co-ordinator of Innis College.

Students entering First Year will be invited to apply for membership after they have been accepted into their Faculty or School. Students entering the Second to Fourth Years who wish to join the College should obtain an application form from the Registrar, Innis College, University of Toronto.

NEW COLLEGE

New College is a multi-faculty co-educational college established in 1962; in addition to students from the Faculty of Arts and Science, those from other Faculties and Schools are eligible for membership. This gives students from all divisions of the University the opportunity to participate in the activities of a college and to associate with students in other fields of study. Individual tutoring is provided for students in some subjects and the Writing Facility offers assistance in written English and French.

The new buildings centrally located on the west campus, provide academic, social and dining facilities for all members of the College and in addition accommodate nearly 300 male students and 380 women students in residence.

Students applying for membership in the College who wish accommodation in the Residence must apply on the prescribed form which may be obtained from the Dean of Men or the Dean of Women, New College.

RESIDENCE ACCOMMODATION

DEVONSHIRE HOUSE

Devonshire House, the University Residence for Men, accepts students from all Faculties. The facilities of the residence include a reading library, common rooms, music practice room, kitchenettes, laundry room, television and games rooms. It does not have a dining hall. Members may take their meals at Hart House, New College, University College Women's Union or Howard Ferguson Hall, all located nearby.

Application forms may be obtained from the Secretary to the Dean, Devonshire House, University of Toronto, Toronto M5S 1A1. Application should be made as early as possible.

NEW COLLEGE

The residence facilities of New College, and the procedure for application, are described in the entry under Colleges, above.

OTHER COLLEGES

Each of the four Arts Colleges also maintains a residence into which some engineering students may be accepted. Further information may be obtained from the Dean of Women or the Dean of Men at University College, Victoria College, Trinity College or St. Michael's College.

HOUSING SERVICE

For students, staff and faculty who require off-campus accommodation, the University displays lists of rooms, apartments and houses in the Housing Service offices at 49 St. George Street, Toronto, Canada M5S 1A1. The places listed are for immediate occupancy, and since the volume of such listings precludes inspection by the University, accommodation cannot be guaranteed nor reserved in advance on behalf of prospective tenants.

Persons from out of town should plan to arrive in Toronto a few days prior to their university commitment, and stay in a hotel while they make permanent arrangements.

UNIVERSITY APARTMENTS

Although unfurnished apartments of this complex were designed to accommodate married students of the University of Toronto, applications from single students may be given consideration should circumstances permit. The apartments are located at 30 and 35 Charles Street, near the St. George campus. More information and applications may be obtained by writing to the University Housing Service, 49 St. George Street, Toronto, Canada, M5S 1A1.

CAMPUS CO-OPERATIVE RESIDENCE INCORPORATED offers residence and apartment accommodation for graduate and undergraduate students. Total occupancy is 300 in residence, half male, half female, and 50 in apartments. Meals are provided, and non-residents are invited to eat at the Co-op Dining Rooms. Since the University of Toronto has no official connection with Campus Co-operative Residence, Inc., inquiries should be addressed direct to Campus Co-operative Residence Incorporated, 395 Huron Street, Toronto, Ontario M5S 2G5.

MARRIED STUDENT APARTMENTS

Apartment accommodation for married students is provided by the Ontario Student Housing Corporation in buildings located in the Bloor-Yonge area. The apartments (bachelor, one-bedroom and two-bedroom units) are unfurnished except for refrigerators, stoves and window drapes. Tenancy is by lease and is restricted to married couples of whom one or other must be registered as a full-time student at the University of Toronto. Additional information and application forms may be obtained at the University Housing Service, 49 St. George Street.

TARTU COLLEGE

Tartu College, opened in 1969, offers accommodation to undergraduate and postgraduate students in 444 single rooms and 15 double rooms. Cooking facilities are provided for groups of six. The rate for single rooms is $103 per month and $80 per month in double rooms. The college is located on Bloor Street at Madison Avenue. Since the University has no official connection with the college, all enquiries should be addressed to the Reservations Office, Tartu College, 310 Bloor Street West, telephone 925-4747.

ST. ANDREW'S–UNIVERSITY DAY NURSERY

This day nursery, established and supported by the University of Toronto, the Graduate

Students' Union and the Students' Administrative Council, provides pre-school education and day care facilities for children of University of Toronto students. Children aged two to five years are accepted.

The nursery, located at St. Andrew's United Church, 117 Bloor Street East, is well equipped and staffed and is licensed under the Day Nursery Act, Province of Ontario. It operates from 8:30 a.m. to 5:45 p.m. throughout the winter and summer academic sessions. Fees are reasonable, and noon meals and morning and afternoon snacks are provided.

Priority of enrolment is given to children of University students, although children of other members of the University community will be considered.

THE UNIVERSITY OF TORONTO CAREER COUNSELLING AND PLACEMENT CENTRE

The Placement Centre, located at 344 Bloor Street West, Fourth Floor, is open from 8:45 a.m. to 5 p.m., each week-day. The staff of the Centre maintain lists of part-time, permanent and summer employment opportunities in a wide variety of fields including the various branches of Engineering. Engineering undergraduates are invited to drop in to discuss careers and employment problems.

Students seeking summer employment should register at the Centre early in the academic term. This is important because job priorities are established on the basis of registration dates. Also, to be eligible for assistance under the Ontario Student Assistance Program, it is necessary for a student who has not obtained summer employment to have both registered at the Placement Centre and to have sought employment. The Centre will provide students who comply with these regulations with a letter for use with his O.S.A.P. applications.

Early registration is also advisable for the Fourth Year permanent employment interviews which are organized by the Centre. Early registrants are given first choice of available interview times.

Students are given an opportunity to explore a variety of careers at a lecture and discussion series regarding careers in industry, government, and the professions, presented by the Centre each year during the month of October. Watch the Varsity and Toike-Oike for specific career topics and dates.

HART HOUSE

All full-time University of Toronto students are members of Hart House. Membership covers a wide variety of activities including concerts, debates, poetry readings and art exhibitions. Students are welcome to use the many rooms as well as the Farm in the Caledon Hills. The House is open from 7:00 a.m. to midnight every day of the year.

Food services are available from 8:00 a.m. to 11:30 p.m.: full-course meals in the Great Hall, table-service in the fully-licensed Gallery Dining Room, a coffee-shop and pub in the Arbor Room and Tuck Shop. For further information about Hart House phone 928-5361.

IV

Fees, Deposits and Expenses

FEES

1. Undergraduate students in the Faculty of Applied Science and Engineering must pay annual fees according to the schedule listed below. The total fee in each case is made up of the academic fee and incidental fees; all incidental fees are payable in the First Term.

Students will receive by mail in August a fees form and instructions for the payment of fees. In order to avoid delay in registration at the opening of the session it is recommended that at least the First Term instalment of fees be forwarded by return mail before August 15.

Fees may be paid by certified cheque, money order or personal cheque payable to the University of Toronto in Canadian funds, and mailed to the Office of the Comptroller, University of Toronto, Toronto M5S 1A2.

2. Payment of at least the First Term instalment must be made before the opening day of the session. A registration card cannot be issued until the student has complied with this requirement.

3. The Second Term instalment of fees, if not already paid, is due on the opening day of the Second Term and must be paid not later than January 15. After this date a penalty will be imposed. All fees for the session must have been paid in full before the student can be admitted to the annual examinations.

4. Fees, residence dues and other charges set forth in this calendar are subject to change by the Governing Council.

SCHEDULE OF FEES

Academic Year	*Academic Fee	†Incidental Fees	Total Fee (if paid in one Instalment)	First Term Instalment	Second Term Instalment
Men					
I–IV	$750	$80	$830	$542	$300

Women					
I–IV	$750	$67	$817	$529	$300

*The Academic Fee includes the following fees:
Tuition; Library and Laboratory Supply; Annual Examinations; Laboratory Fees; and Degree.

† These Incidental Fees include the following fees:
For men – Hart House; Students' Administrative Council; Athletic; Health Service; Engineering Society; Faculty Athletic Association.
For women – Hart House; Students' Administrative Council; Athletic; Health Service; Engineering Society.

FEE FOR RE-CHECKING MARKS

A student who requests that his marks be re-checked must submit with his request a fee of five dollars ($5) for each paper to be checked. The fee is refunded if an error is found.

FEE FOR TRANSCRIPTS

Transcripts of academic record are furnished by the Faculty Office on payment of a fee of $1 for a single copy plus 25 cents for each additional copy requested on the same order.

SPECIAL STUDENTS' FEES

The fee is $115 per course, payable to the Fees Department.

PENALTY FOR LATE REGISTRATION

Any student who registers after the last date for normal registration must petition for acceptance of his registration and is required to pay a late registration fee as follows:

If registering within 7 calendar days–$10
If registering after 7 calendar days–$20

PENALTY FOR LATE SUBMISSION OF PROGRAM DOCUMENTS

A student who fails to submit his pre-registration form or his examination application form by the prescribed date will be subject to a fine of $1 for each day beyond the deadline, to a maximum of $20.

SUMMARY OF STUDENTS' EXPENSES

The following approximate statement of expenses will give the student a general idea of the cost of obtaining an education in the Faculty of Applied Science and Engineering in the University of Toronto, exclusive of personal expenses:

1. Fees, see schedule page 16.	
2. Board and lodging, per week	$30 up
3. Books and instruments, per year	$150 up
4. Miscellaneous personal expenses	$300 up

V

Programs and Degree

UNDERGRADUATE PROGRAMS

The Faculty offers the following programs leading to the degree of Bachelor of Applie Science:

Civil Engineering (Program 1)
Geological Engineering and Applied Earth Science (Program 2)
  Mineral Exploration (Option 2A)
  Mineral Engineering (Option 2B)
  Geotechnical Engineering (Option 2C)
Mechanical Engineering (Program 3)
Industrial Engineering (Program 4)
Engineering Science (Program 5)
  Aerospace (Option 5a)
  Chemical (Option 5c)
  Computer Science (Option 5cs)
  Electrical (Option 5e)
  Geophysics (Option 5g)
  Materials Science (Option 5m)
  Nuclear and Thermal Power (Option 5nt)
  Physics (Option 5p)
Chemical Engineering (Program 6)
Electrical Engineering (Program 7)
Metallurgy and Materials Science (Program 8)

The curricula of the various programs are set out in detail in Section VI. The regulations for standing and promotion are given in Section VII.

PART-TIME STUDY – WOODSWORTH COLLEGE

The first two years of all engineering programs except Engineering Science are also offered through Woodsworth College for students interested in part-time study. The First Year program is available in both day-time and evenings, the Second Year in day-time only. As there is no provision for part-time study in engineering beyond the Second Year, students wishing to complete their studies for the degree must enter into full-time study in the regular courses in the Faculty of Applied Science and Engineering.

Information regarding Part-Time Study may be obtained from the Degree Courses Section, Woodsworth College, 119 St. George Street, University of Toronto, Toronto M5S 1A1.

GRADUATE STUDY AND RESEARCH

Facilities are available in the Departments of the Faculty for postgraduate study and research leading to the degrees of Master of Engineering (M.Eng.), Master of Applied Science (M.A.Sc.), and Doctor of Philosophy (Ph.D.). For further information see the Calendar of the School of Graduate Studies.

SPECIAL STUDENTS

Persons desiring to enroll as Special Students (not proceeding to the degree) should consult the Secretary of the Faculty regarding admission requirements and the procedure for application.

INTERIM HIGH SCHOOL ASSISTANTS' CERTIFICATE TYPE A

Graduates of engineering programs may be admitted to Type A certificate courses at The Faculty of Education, University of Toronto, if they submit official transcripts which indicate that they have sufficient academic credits.

Graduates of engineering programs who lack sufficient academic credits for admission to Type A courses at the Faculty of Education may be eligible for admission to the Type B course and later for endorsement of the Type B certificate.

Inquiries regarding admission to the Type B course should be addressed to the Registrar, Faculty of Education, University of Toronto. Inquiries regarding endorsement of Type B certificates or admission to Type A certificate courses should be addressed to the Director, Committee on Advanced Standing, Faculty of Education, University of Toronto.

ASSOCIATIONS OF PROFESSIONAL ENGINEERS

Graduation from the Faculty of Applied Science and Engineering leads to registration as a Professional Engineer in the various Associations of Professional Engineers throughout Canada.

VI

Curriculum

The curriculum is based upon a term system in which all courses of instruction (with th exception of certain courses taken in the Faculty of Arts and Science) are one term i duration. There are two terms in the annual session, each concluding with final examinations in the courses offered. With the exception of the First Year, for which there ar special provisions, students will be evaluated for promotion at the end of each term.

The curriculum provides a good deal of latitude to the student in choosing his progran of study. A regular program consists of a maximum of six courses per term with a tota weight of 48 units; with the approval of the Chairman of his Department a student enrolle in the second or higher years may elect to reduce his load to a minimum of 40 units pe term, or to increase it to a maximum of 60 units per term.

On the following pages of this section the curriculum of each program is set forth i detail. A common curriculum for students in First Year forms a basis in the fundamenta subjects prior to subsequent specialization in various engineering disciplines. The studen is able to choose from a wide range of technical electives in the senior years, and in th Fourth Year, all programs contain a thesis, which provides the student with the opportunity to carry out original work in his chosen field of study.

As a guide to students in apportioning their time, a weight factor is shown opposite each course of instruction. The weight factor represents the number of hours per week including both scheduled class-room time and home work, that the average student i expected to devote to that course. This weight factor is also used in the computation of the student's weighted average in the work of the term.

The program and regulations contained in this Calendar hold good for this academi year only, and the Faculty of Applied Science and Engineering does not bind itself t adhere for the whole period of a student's attendance to the conditions here laid down.

ELECTIVE COURSES

Elective courses fall into four categories, viz. Technical Electives; Non-Technical Electives (in First and Second Year); Open Electives (in Third Year) and Free Electives (ir Fourth Year). In general, the student must not select elective courses which would involve excessive duplication of material covered elsewhere in his program. The following paragraphs provide further instructions on the selection of elective courses:

1. TECHNICAL ELECTIVES: These are specified in the prescription for the program in which the student is registered. In most cases the choice is restricted to a specified list of available Technical Electives. The availability of a particular elective course may depend on a sufficient number of students wishing to take it; in a few courses it may be necessary to limit the number of students enrolled.

2. NON-TECHNICAL ELECTIVES (First and Second Year): Each student in the First and Second Year must include in his program a Non-Technical Elective in each term. In general, acceptable Non-Technical Electives have as their central theme the study of man as an individual or of man as a social being. Courses that are not acceptable are those that have an appreciable mathematical or technical content.

The following courses have been arranged specifically for students of the Faculty of Applied Science and Engineering, and have been scheduled on Mondays and Wednesdays at 1, and Tuesdays and Thursdays at 12, so as to be available to all students. The work load in these courses is compatible with the student's work load in Engineering courses. For descriptions of the courses listed below see Outline of Courses, page 82.

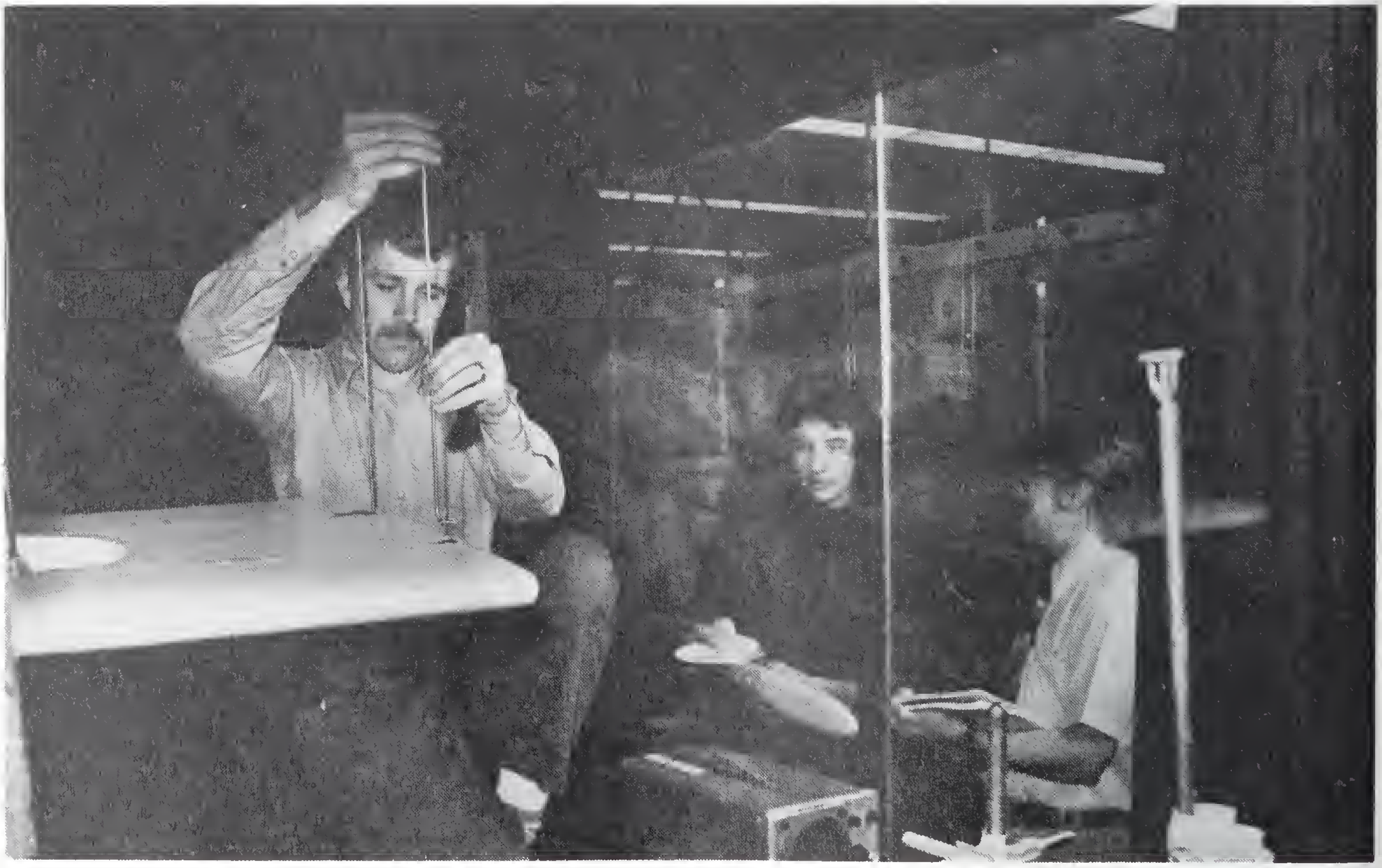
ECO 281	Economics
ENG 281F/S	Effective Writing
ENG 282F/S	Twentieth Century Literature
ENG 283F/S	Canadian Literature
ENG 284F/S	Varieties of Fiction
ENG 285F/S	Drama and the Modern Theatre
ENG 286F/S	Literature and Science
ENG 287S	Special Studies in English
HPS 280F/S	History of Science and Technology
HPS 281F	History of Technology and Engineering up to the Industrial Revolution
HPS 282S	History of Technology and Engineering from the Industrial Revolution to the Present
HPS 283S	Technology, Engineering and Society
PHL 291F	Science and Society
PHL 292S	Science and Philosophy

Students desiring a broader choice in their Non-Technical Electives may obtain from the Faculty Office or their Departmental Offices, information concerning courses offered by the Faculty of Arts and Science and other faculties and schools in the University which are acceptable as Non-Technical Electives. These courses encompass a broad range, including languages, history, philosophy, anthropology, psychology, economics, political science, etc. Students are cautioned that some of these courses may require a larger commitment of time than those courses which have been arranged specifically for the Faculty of Applied Science and Engineering.

3. OPEN ELECTIVES (Third Year only): In each term of the Third Year there is provision for an Open Elective which the student must fill. Courses acceptable as Open Electives are (i) any course which is acceptable as a Non-Technical Elective as defined in section above, or (ii) excluding courses offered by the Faculty of Applied Science and Engineering, any degree credit course listed in a current calendar of the University of Toronto, its constituent colleges, federated colleges, or federated universities. Students selecting courses in category (ii) must obtain the approval of the teaching department offering the course.

A student in the Third Year whose technical program involves 16 or more units per term taken outside the Faculty may be permitted to choose a course offered within the Faculty as his Open Elective.

4. FREE ELECTIVES (Fourth Year only): In each term of the Fourth Year there is provision for a Free Elective which the student must fill. Any degree credit course listed in a current calendar of the University of Toronto, its constituent colleges, federated colleges, or federated universities is acceptable as a Free Elective, subject to approval of enrolment by the teaching department offering the course. If taken within the Faculty of Applied Science and Engineering, the Free Elective must be a course carrying a weight of at least 6 units per term.



First Year Studies

Chairman For First Year Studies:
P. I. P. Boulton, B.A.SC., M.A.SC., PH.D., Department of Electrical Engineering

Coordinating Staff:

C. E. Chaffey, B.SC., PH.D. (McG.), Department of Chemical Engineering
W. Janischewskyj, M.A.SC., Department of Electrical Engineering
W. A. Miller, PH.D. (McG.), Department of Metallurgy and Materials Science
M. R. Piggott, M.SC., PH.D. (LOND.), Department of Chemical Engineering
R. A. Ross, M. A., PH.D., Department of Mathematics
S. Sandler, M.A.SC., Department of Chemical Engineering
S. D. Scott, M.SC., PH.D., Department of Geology
I. W. Smith, B.A.SC., M.A.SC., Department of Mechanical Engineering
M. A. Townsend, M.S. (ILL.), PH.D. (WISC.), Department of Mechanical Engineering
G. T. Will, B.A.SC., M.A.SC., Department of Civil Engineering
R. T. Woodhams, M.SC. (U.W.O.), PH.D. (BKLYN), Department of Chemical Engineering
C. A. Wrenshall, B.E. (SASK.), Department of Civil Engineering

FIRST YEAR STUDIES

In his first year of studies, an engineering student must establish a strong foundation in the basic disciplines which underlie the whole field of engineering. The First Year program has been designed to this end, providing for courses in mathematics and the physical, chemical and engineering sciences. In addition, the student is given an opportunity to broaden his education and outlook by making essentially all of the non-technical courses of the university accessible to him through the Non-Technical Electives. There are two First Year curricula – Engineering, the standard curriculum, and Engineering Science, the enriched curriculum.

The Engineering Science curriculum is designed for students who intend to continue in one of the following options in Third Year: Aerospace, Chemical, Computer Science, Electrical, Geophysics, Materials Science, Nuclear and Thermal Power, and Physics.

Admission to the First Year Engineering Science curriculum is granted only to thos students with better than average ability in mathematics and the sciences. Student undertaking this curriculum must maintain satisfactory term and year averages in thei first year work in order to pursue the Engineering Science program in their second year Transfers from Engineering Science to any other program are freely permitted fo students in good standing at the end of the first term or the first year.

The engineering curriculum is designed for students who intend to continue in one o the following programs in Second Year: Civil Engineering, Geological Engineering an Applied Earth Science, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Electrical Engineering, and Metallurgy and Materials Science. Students mus elect one of these programs on entering the First Year, and this election guarantees a plac in that program in Second and subsequent years, subject to maintenance of satisfactor term and year averages. Subject to the availability of places, any student who successfull completes the First Year in one of the above programs may request to transfer to an other of these programs. Because of the special nature of the Engineering Scienc curriculum, transfers from these programs to Engineering Science are not possible except in extraordinary cases.

Students wishing to transfer to a different program at the end of First Year should make application to the Secretary of the Faculty not later than July 15.

FIRST YEAR CURRICULUM — ENGINEERING

Civil Engineering
Geological Engineering and Applied Earth Science
Mechanical Engineering
Industrial Engineering
Chemical Engineering
Electrical Engineering
Metallurgy and Materials Science

Term 1F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Computer Programming[†]	APS 100F/S	1	—	3	7
Engineering Graphics[†]	CIV 135F/S	2	5	—	8
Applied Mechanics	CIV 100F	3	—	2	10
Calculus I	MAT 186F	2	—	2	6
Algebra I	MAT 188F	2	—	2	6
Non-Technical Elective[*]					8
and one of:					
Chemistry	CHE 111F	3	3	1	12
Chemistry	CHE 112F	3	3	1	12
Chemistry	CHE 113F	3	3	1	12

[†] One half of the students in Engineering will take Computer Programming in Term 1F; the other half will take Engineering Graphics. The arrangement is reversed in Term 1S.

[*] Students will select one Non-Technical Elective course each term. See page 21 of the Calendar.

FIRST YEAR CURRICULUM — ENGINEERING

Term 1S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Computer Programming†	APS 100F/S	1	—	3	7
Engineering Graphics†	CIV 135F/S	2	5	—	8
Electricity and Magnetism	ELE 121S	3	1	1	10
Calculus II	MAT 187S	2	—	2	7
Algebra II	MAT 189S	2	—	2	6
Non-Technical Elective*					8
△**and one of:**					
Engineering Design	APS 101S	2	$1^1/_2$	1	8
Chemical Engineering**	CHE 101S				8
Applied Physical Geology	GLG 180S	3	$1^1/_2$	—	8
Structure and Properties of Matter	MMS 100S	3	$1^1/_2$	—	8

†One half of the students in Engineering will take Computer Programming in Term 1F; the other half will take Engineering Graphics. The arrangement is reversed in Term 1S.

*Students will select one Non-Technical Elective course each term. See page 21 of the Calendar.

△None of these Technical Electives shall be pre-requisite for any course given in a subsequent term. Any elective in which there is insufficient enrolment may be withdrawn.

**Students select three projects from a provided list, for which the contact times may vary from 3 hours of lectures to $7^1/_2$ hours of laboratory weekly.

FIRST YEAR CURRICULUM — ENGINEERING SCIENCE

Term 1F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Mechanics (Statics)	CIV 101F	2	—	1	6
Chemistry#	CHE 150F	3	3	1	10
Introduction to Computer Programming	CSC 180F	2	2	—	6
Calculus I	MAT 194F	3	—	2	10
Elements of Physics I (Mechanics)	PHY 180F	2	1½	1	9
Non-Technical Elective*					8
Term 1S					
Electricity	ELE 150S	3	—	—	8
Linear Algebra	MAT 185S	2	—	1	8
Calculus II	MAT 195S	3	—	1	7
Elements of Physics II (Thermodynamics and Statistical Physics)	PHY 181S	3	1½	1	9
Non-Technical Elective*					8
△and one of:					
Engineering Design	APS 101S	2	1½	1	8
Chemical Engineering**	CHE 101S				8
Engineering Graphics	CIV 136S	2	—	2½	8
Applied Physical Geology	GLG 180S	3	1½	—	8
Structure and Properties of Matter	MMS 100S	3	1½	—	8

#Students who have not had Grade 13 Chemistry or the equivalent may petition for permission to substitute CHE 111F for CHE 150F.

*Students will select one Non-Technical Elective course each term. See page 21 of the Calendar.

△None of these Technical Electives shall be pre-requisite for any course given in a subsequent term. Any elective in which there is insufficient enrolment may be withdrawn.

**Students select three projects from a provided list, for which the contact times may vary from 3 hours of lectures to 7½ hours of laboratory weekly.

Civil Engineering

Professor and Chairman of the Department:
G. W. Heinke, B.A.SC., M.A.SC., PH.D.(McM.)

Professors:
F. A. DeLory, B.ENG.(McG.), M.A.SC., D.I.C.(IMP.), PH.D.(LOND.)
C. Hershfield, B.SC., C.E.(MAN.), M.A.SC.
M. W. Huggins, B.A.SC., M.A.SC.
P. H. Jones, B.A.SC., M.S.(NORTHWEST.), PH.D.(NORTHWEST.)
T. C. Kenney, B.ENG.(McG.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.)
R. H. Mills, B.SC.(WITWATERSRAND)
J. Schwaighofer, DIPL. ING.(GRAZ), M.S.(PENN. ST.), PH.D.(PENN. ST.), DR. TECH.(GRAZ)
R. M. Soberman, B.SC.(DAL.), PH.D.(M.I.T.)
C. A. Wrenshall, B.E.(SASK.)

Associate Professors:
J. D. Barber, B.A.SC., M.A.SC.
A. P. Bernhart, DIPL. ING.(GRAZ) DR. TECH.(GRAZ)
P. C. Birkemoe, B.SC.E., M.S.(PURDUE), PH.D.(ILL.)
M. P. Collins, B.E.(CANTERBURY), PH.D.(N.S.W.)
R. A. Collins, B.A.SC., M.S.(ILL.), PH.D.(ILL.)
A. C. Davidson, B.SC., C.E., B.SC., E.E.(MAN.), M.A.SC.
M. M. Davis, B.SC.(QU.), M.SC.(PURDUE)
H. R. Frizzle, B.SC., E.E.(N.S.TECH.)
J. Ganczarzyk, M.SC., D.SC.(GLIWICE), D.SC.,(WARSAW)
E. Hauer, B.SC., M.SC.(TECHNION), PH.D.(CALIF.)
B. J. Haynes, B.A.SC.
J. G. Henry, B.SC.(QU), M.S.E.(PRINCETON), PH.D.
H. L. Macklin, B.A.SC.
V. R. Riley, B.A.SC., PH.D.(CANTAB.)

E. I. Robinsky, B.A.(BEIRUT), B.SC.(BEIRUT), M.S.(HARVARD), PH.D.
K. A. Selby, B.A.SC., M.B.A., PH.D.(ILL.)
G. N. Steuart, B.SC.(SASK.), M.SC.(CALIF.), PH.D.(CALIF.)
J. Timusk, B.A.SC., M.A.SC., PH.D.(LOND.)
S. M. Uzumeri, B.A.SC., M.A.SC.
J. Vlcek, B.SC.F.(N.B.), M.A.SC., D.SC.(BRATISLAVA)
P. M. Wright, B.E., M.SC.(SASK.), PH.D.(COLO.)

Assistant Professors:
M. Kalin, DIPL. NAT.(ETH ZURICH), DR.SC.NAT.(ETH ZURICH)
K. Meipoom, B.A.SC., M.A.SC.
G. T. Will, B.A.SC., M.A.SC.

Lecturers:
V. P. Borecky, DIPL. ING.(PRAGUE), M.A.
Mrs. E. Kuhn, DIPL. ING.(BRATISLAVA), M.A.SC.
R. G. Rice, B.A.SC., M.SC.(M.I.T.)

Special Lecturers:
R. D. Foster, M.A.SC.
A. P. Goel, B.E.,M.E.(ROORKEE), M.A.SC.
J. D. Morton, B.SC.(DURHAM), D.I.C.(IMP.), M.ENG.
P. E. Wisner, DIPL. ING.(BUCHAREST), PH.D.(BRNO)

CIVIL ENGINEERING

Program I

Civil Engineering as a profession is concerned with improving man's environment through the planning, designing and construction of facilities such as dams, buildings, transportation systems and municipal services. These activities encompass a very wide range of knowledge and this in turn creates special curriculum problems.

The program in Civil Engineering is arranged so that a student may undertake either a relatively broad study of the discipline or a more comprehensive examination of one of its principal fields (structural, municipal and sanitary, transportation, geotechnical, and surveying). This flexibility is derived from the fact that a Fourth Year student's program consists mainly of elective courses and a thesis. The departmental electives are time-tabled so as to maximize the freedom of students to take the electives of their choice. Several project-oriented courses in the Second Year program provide students with an understanding of the engineering approach to planning and design.

In summary, the program is designed to develop well-informed creative engineers possessing innovative and directive capabilities.

SECOND YEAR CIVIL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Strength of Materials	CIV 210F	3	—	1	8
Surveying	CIV 255F	3	2	1	9
Computer Programming	CIV 260F	2	—	2	8
The Engineer and his Environment	CIV 267F	2	2	2	8
Calculus	MAT 280F	3	—	2	9
Non-Technical Elective					8
Term 2S					
Engineering Materials	CIV 209S	4	2	1	10
Mechanics and Design of Structures	CIV 211S	4	—	2	10
Environmental Systems	CIV 240S	2	—	—	5
Probability and Statistics	CIV 271S	3	—	2	8
Practical Experience	APS 299	—	—	—	—
Geology* or Basic Science Course	GLG 280S	2	$1\frac{1}{2}$	1	8
Non-Technical Elective					8

*Students who have taken GLG 180S in First Year must replace GLG 280S by a Basic Science Course, normally PHY 282S. Students who have not taken GLG 180S must replace one Technical Elective in the Third or Fourth Years by a Basic Science Course.

THIRD YEAR CIVIL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Design of Structures II	CIV 312F	3	—	2	9
Soil Mechanics	CIV 321F	2	1	—	6
Transportation Systems	CIV 330F	3	—	2	8
Survey Camp*	CIV 358F	—	—	—	8
Engineering Mathematics	CIV 370F	3	—	2	8
Fluid Mechanics	MEC 351F	3	3	—	10
Open Elective					8

*Survey Camp is taken prior to the commencement of regular courses in Third Year and the results included with those for the subsequent term on the basis of a weighting of 8 units.

THIRD YEAR CIVIL ENGINEERING (CONTINUED)

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Design of Structures III	CIV 313S	3	—	2	10
Foundations	CIV 322S	2	—	2	7
Municipal Engineering	CIV 340S	2	—	2	7
Civil Engineering Systems	CIV 368S	2	2	2	8
Technical Elective**		3	—	2	8
Open Elective					8

FOURTH YEAR CIVIL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Administration and Management	CIV 475F	2	—	—	6
Technical Elective**		3	—	2	8
Technical Elective		3	—	2	8
Technical Elective		3	—	2	8
Technical Elective		3	—	2	8
Free Elective					8
Term 4S					
Public Speaking	CIV 474S	—	—	2	3
Thesis	CIV 499S	—	6	—	12
Technical Elective		3	—	2	8
Technical Elective		3	—	2	8
Technical Elective		3	—	2	8
Free Elective					8

**Technical Electives. During Third and Fourth Year, students select eight Technical Electives. Each student is advised to consult with a member of the staff in establishing the electives in his program. The Technical Electives offered by the Department of Civil Engineering are given below.

*Fall Term Electives***

CIV 405F	Advanced Strength of Materials
CIV 413F	Modular Construction
CIV 416F	Reinforced Concrete I
CIV 419F	Indeterminate Structures
CIV 421F	Foundations and Earthwork
CIV 429F	Air Photo Interpretation
CIV 430F	Traffic Engineering
CIV 431F	Transportation Planning
CIV 440F	Water and Pollution Control Engineering
CIV 450F	Water Resources and Hydrology
CIV 455F	Photogrammetry and Remote Sensing
CIV 479F	Special Studies in Civil Engineering
CIV 498F	Thesis†

†With the permission of the Chairman of the Department, a student may elect to undertake a 20-unit thesis by taking both CIV 498F and CIV 499S.

*Spring Term Electives***

CIV 338S	*Urban and Regional Planning Techniques
CIV 375S	*Engineering Economics and Decision Making
CIV 414S	*Advanced Engineering Materials
CIV 417S	Reinforced Concrete II
CIV 418S	Behaviour and Design of Steel Structures
CIV 420S	Construction Engineering
CIV 422S	*Engineering Geology
CIV 432S	Highway Engineering
CIV 439S	Urban and Regional Planning
CIV 441S	Air Pollution Control Engineering
CIV 456S	*Engineering Applications of Surveying
CIV 479S	Special Studies in Civil Engineering
MEC 452S	Hydraulic Engineering

*Available to Third and Fourth Year students.

**With the approval of the Chairman of the Department a student may include, as part of his elective program, courses that are offered outside the Department provided that the University Department, Faculty or Institute offering the course has agreed to accept him for that course.

Geological Engineering and Applied Earth Science

FACULTY MEMBERS OF THE DIVISION

Chairman of the Division:

F. A. DeLory, B.ENG.(McG.), M.A.SC., D.I.C.(IMP.), PH.D.(LOND.), *Professor of Civi Engineering*

Members of the Division:

J. B. Currie, B.A.(McM.), M.A., PH.D., *Professor of Geology*

D. H. Gorman, B.SC., PH.D., *Associate Professor of Geology*

T. C. Kenney, B.ENG.(McG.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.), *Professor o Civil Engineering*

R. T. McAndrew, B.SC., M.SC.(QU.), PH.D.(U.B.C.), *Associate Professor of Metallurgy and Materials Science*

A. J. Naldrett, B.A., M.SC., PH.D., *Professor of Geology*

H. U. Ross, C.D., M.SC.(McG.), *Professor of Metallurgical Engineering*

D. W. Strangway, M.A., PH.D., *Professor and Chairman*, Department of Geology

GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

Program 2

Geological Engineering and Applied Earth Science is an interdisciplinary program that emphasizes the engineering application of earth science to professional activities related to the materials of the earth. The range of activities involved includes exploration for energy and mineral resources, development and control of the methods of removing minerals from the earth and of processing minerals to yield metals, protection of the environment in the development of earth materials, and geotechnical problems involved in construction with earth materials. Geological Engineering might be summarized as: The combination of the science of geology with the principles of engineering in the use of materials of the earth for the convenience of man in compatibility with the environment.

The program is an interfaculty one for which the specialized core of geological study is provided by the Department of Geology (Faculty of Arts and Science) while several departments in the Faculty of Applied Science and Engineering, particularly the Department of Civil Engineering and the Department of Metallurgy and Materials Science, contribute instruction in Engineering subjects. The First Year of the four year program is the Engineering curriculum (see page 24). The Second Year is unique to the Geological Engineering and Applied Earth Science program and emphasizes training in geology, mathematics, basic and material science and acquaints students with the areas of professional activity in the various fields of Geological Engineering. For the Third and Fourth years, students choose one of the three options listed below. Within each option there are elective courses and therefore programs of study have considerable flexibility and the students can arrange programs to suit their interest, aptitudes and needs.

Option A, Mineral Exploration provides a thorough grounding in basic geology including mineralogy, structure, petrology and stratigraphy. In addition it includes courses in Exploration Geochemistry and Geophysics, and in Mineral Deposits and Petroleum Geology. Students can round out their education with courses in Mining and Mineral Processing, courses dealing with the properties of soils, or courses related to control of the environment.

Option B, Mineral Engineering, which is concerned with the concentration and processing of the valuable contents of the products of mining operations, emphasizes mineralogy n addition to basic physics and chemistry. Students will undertake specialized courses in he subject in the last two years of the Program.

Option C, Geotechnical Engineering, represents the area relating Geology to Civil Engineering and Regional Planning. In the first two years students take a number of courses n basic geology and engineering. In the final two years, the program includes courses which qualify students to identify "geological hazards" affecting the design and safety of specific engineering projects, to carry out the design of structures in or on natural materials and to review regional planning proposals to safeguard against the deterioration of our environment.

ECOND YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

erm 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
trength of Materials	CIV 210F	3	—	1	8
Introductory Mineralogy and Petrology	GLG 220	2	3	—	9
Calculus	MAT 280F	3	—	2	9
Introduction to Mineral Engineering	MMS 224F	2	—	1	7
Non-Technical Elective					8

SECOND YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE (CONTINUED)

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
and one of:					
Principles of Physical Geology*	GLG 120F	2	2	1	9
Basic Classical and Modern Physics	PHY 283F	3	—	—	8
Introduction to Modern Physics	PHY 282F	3	—	—	8
Term 2S					
Probability and Statistics	CIV 271S	3	—	2	8
Topics in Geological Engineering	GLE 201S	2	—	2	7
Principles of Historical Geology	GLG 122S	2	2	1	9
Introductory Mineralogy and Petrology	GLG 220	2	3	—	9
Materials Chemistry	MMS 226S	2	—	2	8
Non-Technical Elective					8
Field Trip	GLG 315F	—	—	—	—
Practical Experience	APS 299	—	—	—	—

*This course is required of students who have not taken GLG 180S. Students taking GL 120F must take either PHY 283F, PHY 282F or an equivalent Basic Science Course an elective course in Third or Fourth Year.

THIRD YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENC

With the approval of the Chairman of the Division, Third Year students may include, a part of their elective program, courses other than those shown as electives. In genera substitutions must avoid timetable clashes and be the same type of course as the liste electives, i.e. an Engineering course substituting for an elective Engineering course.

OPTION A (Mineral Exploration)

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt*
Field Trip	GLG 315F	—	—	—	—
Petrology	GLG 320	2	3	—	8
Stratigraphy and Sedimentation	GLG 321F	1	3	—	8
Tectonics	GLG 322	1	3	—	8
Phase Diagrams for Geologists	GLG 330F	2	—	1	8
Open Elective					8
and one of:					
Soil Mechanics	CIV 321F	2	1	—	6
Mining Technology I	GLE 328F	3	—	1	8
Air Photo Interpretation	CIV 429F	3	2	—	8

THIRD YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE (CONTINUED)

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Petrology	GLG 320	2	3	—	8
Tectonics	GLG 322	1	3	—	8
Geology of the Canadian Shield	GLG 327S	1	3	—	8
Introduction to Geochemistry	GLG 331S	3	—	—	8
Open Elective					8
and one of:					
Foundations	CIV 322S	2	—	2	7
Pleistocene Geology	CIV 327S	3	—	2	8
Mining Technology II	GLE 329S	3	—	1	8
Field Camp	GLG 425F	—	—	—	—

OPTION B (Mineral Engineering)

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Field Trip	GLG 315F	—	—	—	—
Mining Technology I	GLE 328F	3	—	1	8
Petrology	GLG 320	2	3	—	8
Mineral Processing I	MMS 301F	2	3	1	8
Minerals Equilibria	MMS 309F	3	—	2	8
Open Elective					8
and one of:					
Mass Transfer Operations I	CHE 312F	2	—	2	9
Soil Mechanics	CIV 321F	2	1	—	6
Term 3S					
Fluid Mechanics	CHE 314S	3	1½	1	10
Petrology	GLG 320	2	3	—	8
Extractive Metallurgy	MMS 310S	4	3	—	9
Mineral Processing II	MMS 412S	2	1½	—	7
Open Elective					8
nd one of:					
Introduction to Geochemistry	GLG 331S	3	—	—	8
Mining Technology II	GLE 329S	3	—	1	8
Field Camp	GLG 415F	—	—	—	—

THIRD YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE (CONTINUED)

OPTION C (Geotechnical Engineering)

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Field Trip	GLG 315F	—	—	—	—
Soil Mechanics	CIV 321F	2	1	—	6
Engineering Mathematics	CIV 370F	3	—	2	8
Stratigraphy and Sedimentation	GLG 321F	1	3	—	8
Tectonics	GLG 322	1	3	—	8
Fluid Mechanics	MEC 351F	3	3	—	10
Open Elective					8

Term 3S					
Foundations	CIV 322S	2	—	2	7
Pleistocene Geology	CIV 327S	3	—	2	8
Structural Design	CIV 314S	2	—	3	8
Tectonics	GLG 322	1	3	—	8
Open Elective					8
and one of:					
Urban and Regional Planning Techniques	CIV 338S	3	—	2	8
Probability and Statistics	STA 282S	2	—	2	8
Field Camp	GLG 425F	—	—	—	—

FOURTH YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

With the approval of the Chairman of the Division, Fourth Year students may include, part of their elective program, courses other than those shown as electives. In genera substitutions must avoid timetable clashes and be the same type of course as the liste electives, e.g. an Engineering course substituting for an elective Engineering course.

OPTION A (Mineral Exploration)

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Field Camp	GLG 425F	—	—	—	—
Mineral Deposits	GLG 421	2	3	—	8
Exploration Geochemistry	GLG 480	2	3	—	8
Petroleum Geology	GLG 428F	2	3	—	8
Exploration Geophysics	PHY 338X	2	3	—	8
Free Elective					8

OURTH YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH CIENCE (CONTINUED)

erm 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
nd one of:					
Soil Mechanics	CIV 321F	2	1	—	6
Water and Pollution Control Engineering	CIV 440F	3	—	2	8
Photogrammetry and Remote Sensing	CIV 455F	3	2	—	8
Computer Application in the Geological Sciences	GLG 450	—	—	4	8
erm 4S					
lineral Deposits	GLG 421	2	3	—	8
xploration Geochemistry	GLG 480	2	3	—	8
hesis	GLE 492S	—	6	—	8
xploration Geophysics	PHY 338X	2	3	—	8
ree Elective					8
nd one of:					
Mine Operation and Administration II	GLE 427S	2	—	3	8
Sedimentary Processes	GGR 311S	1	1	—	6
Groundwater Geology	GLG 429S	2	3	—	8
Computer Application in the Geological Sciences	GLG 450	—	—	4	8
PTION B (Mineral Engineering)					
erm 4F					
ield Camp	GLG 415F	—	—	—	—
ineral Deposits	GLG 421	2	3	—	8
ydrometallurgy	MMS 413F	2	1½	1	8
ineral Engineering	MMS 414F	2	3	1	9
ee Elective					8
d two of:					
Mine Operation and Administration I	GLE 426F	2	—	3	8
Electrical Systems	ELE 470F	3	3	—	9
Operational Research I	IND 301F	2	—	2	8
Thesis*	GLE 493	—	6	—	8
Electro-Chemical and Kinetic Processes	MMS 302F	2	—	4	8

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he thesis generally extends through the Fall and Spring Terms. A shorter one-term esis may be selected with the approval of the thesis supervisor.

FOURTH YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE (CONTINUED)

Term 4S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Mineral Deposits	GLG 421	2	3	—	8
Physics and Chemistry of Surfaces	MMS 415S	2	—	1	8
Thesis	GLE 493	—	6	—	8
or	GLE 494S	—	6	—	8
and two of:					
Environmental Engineering	CHE 423S	2	—	1	7
Mine Operation and Administration II	GLE 427S	2	—	3	8
Operational Research II	IND 302S	2	—	2	8
Metallurgical Systems Analysis	MMS 407S	2	—	1	7

OPTION C (Geotechnical Engineering)

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Field Camp	GLG 425F	—	—	—	—
Rock Mechanics	CIV 424F	3	—	2	8
Subsurface Exploration	CIV 425F	3	—	2	8
Administration and Management	CIV 475F	2	—	—	6
Free Elective					8
and two of:					
Foundations and Earthwork	CIV 421F	3	—	2	8
Water and Pollution Control Engineering	CIV 440F	3	—	2	8
Water Resources and Hydrology	CIV 450F	3	—	2	8
Photogrammetry and Remote Sensing	CIV 455F	3	2	—	8
Exploration Geophysics	PHY 338X	2	3	—	8
Thesis*	GLE 495	—	6	—	8
Term 4S					
Engineering Geology Seminars	CIV 423S	3	—	2	8
Groundwater	CIV 449S	2	—	3	8
Design of Earth and Rock Structures	CIV 428S	2	—	3	8
Thesis	GLE 495	—	6	—	8
or	GLE 496S	—	6	—	8
Free Elective					8

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*With the permission of the Chairman of the Division a student may elect to undertake 16 unit thesis.

FOURTH YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
and one of:					
Construction Engineering	CIV 420S	3	—	2	8
Sedimentary Processes	GGR 311S	1	1	—	6
Hydraulic Engineering	MEC 452S	3	2	—	8
Exploration Geophysics	PHY 338X	2	3	—	8

Mechanical Engineering

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D. McCammond, B.SC.(QU. BELFAST), PH.D.(QU. BELFAST)

Special Lecturer:
G. D. Ransford, B.A., B.C.E.(MELBOURNE), ING.D.(GRENOBLE)

MECHANICAL ENGINEERING

Program 3

The discipline of Mechanical Engineering has developed from the construction of machines beneficial to man. It is now, however, much more than the design, fabrication and operation of these machines because of the expertise which the Mechanical Engineer possesses. As a student he receives a background training in applied mechanics, hermodynamics, fluid mechanics, control theory and material science, which are all studies of the physical principles on which the machines are based. In addition he receives analytical training in mathematics to provide the means of inter-relating the physical phenomenon and operational concepts. All of the specialties meet in the design process which is taught through the use of projects. One develops the thinking process by which new devices are conceived through the design and fabrication of original machines. It is here that the student must also learn to appreciate social implications of engineering such as concern for the environment, conservation of energy and the economic consequences of his creation.

Virtually the whole spectrum of primary and secondary industries seeks the practising Mechanical Engineer as an employee or a consultant. The largest concentrations are ound in the primary power production industry where hydraulic, thermal, and nuclear nergy is converted to electricity; in the manufacture of automobiles, aircraft and other mass transportation equipment; in the heating and air-conditioning industry where the nvironmental control of buildings is established, and in the primary metal producing ndustries. Some Mechanical Engineers are associated with smaller organizations such as hose in the medical equipment and noise control fields, in the management of large and mall industries and in education.

The Second and most of the Third Year curriculum in the course is devoted to ackground studies. Design laboratories are introduced later in the Third Year and arried on throughout the Fourth Year. At the same time, the student can choose electives o suit his talents and inclinations. He can sharpen his understanding of the fundamentals n preparation for graduate work, for employment in research and development areas, or e can concentrate on groups of subjects leading to association with specific industries, uch as central power station design or environmental control.

For the First Year curriculum see Engineering, page 24.

SECOND YEAR MECHANICAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Engineering Law	APS 300F	1	—	—	2
Circuit Theory and Measurements	ELE 270F	3	1½	1½	10
Calculus	MAT 293F	2	—	2	8
Mechanics of Deformable Bodies I	MEC 211F	3	¾	2¼	10
Differential Equations	MEC 261F	3	—	3	10
Non-Technical Elective					8

Term 2S		*Lect.*	*Lab.*	*Tut.*	*Wt*
Electromechanical Energy Conversion	ELE 272S	3	1½	1½	8
Dynamics I	MEC 201S	3	—	1½	8
Mechanics of Deformable Bodies II	MEC 212S	3	¼	1¼	8
Materials Science	MMS 223S	3	1½	—	8
Metrology	MEC 262S	3	—	2	8
Non-Technical Elective					8

THIRD YEAR MECHANICAL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt*
Thermodynamics	MEC 321F	3	1	2	10
Fluid Mechanics I	MEC 341F	3	2	1	10
Analysis and Design of Mechanisms	MEC 371F	3	—	3	10
Engineering Analysis I	MEC 362F	3	—	3	10
Open Elective***					8
Term 3S					
Thermal Energy Conversion	MEC 322S	3	3	—	10
Vibrations	MEC 303S	3	1	2	10
Engineering Analysis II	MEC 363S	3	—	3	10
Technical Elective**					10
Open Elective***					8

TECHNICAL ELECTIVES**

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt*
Combustion Theory	MEC 323S	3	—	1½	10
Dynamics II	MEC 302S	3	—	1½	10
Elasticity	MEC 313S	3	—	1½	10
Fluid Mechanics II	MEC 342S	3	—	1½	10

FOURTH YEAR MECHANICAL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Control Systems I*	MEC 455F/S	3	1½	1½	10
Heat and Mass Transfer*	MEC 431F/S	3	1½	1½	9
Thesis of Design Project	MEC 499	—	—	—	11
Basic Science Elective***					8
Technical Elective					10
Free Elective					8
Term 4S					
Design	MEC 472S	2	—	6	10
Applied Fluid Mechanics	MEC 443S	3	3	—	9
Control System I*	MEC 455F/S	3	1½	1½	10
Heat and Mass Transfer*	MEC 431F/S	3	1½	1½	9
Thesis of Design Project	MEC 499	—	—	—	3
Technical Elective**					10
Free Elective***					8

*Half of the students will take Control Systems I in the Fall Term and Heat and Mass Transfer in the Spring Term. The other half of the students will take the reciprocal arrangement.

**Technical Electives offered in the terms 3S and 4S are equally available to Third and Fourth Year Students. Third Year students require the consent of the instructor if enrolling in a Fourth Year elective. With the approval of the Chairman of the Department, any other suitable course given by the Faculty of Applied Science and Engineering may be substituted as a Technical Elective. Department electives for which there is insufficient demand may be withdrawn.

**A student must include a basic science course in his program. Some acceptable courses are:

PHY 215F	Geophysics
PHY 282F/S	Introduction to Modern Physics
PHY 283F	Basic Classical and Modern Physics
PHY 332F	Molecular Biophysics
PHY 333S	Cellular Biophysics
PHY 384F	Thermodynamics, Statistical Mechanics
PHY 480F	Modern Physics
CHM 324F	Crystal Chemistry

FOURTH YEAR MECHANICAL ENGINEERING (CONTINUED)

TECHNICAL ELECTIVES**

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thermal Power Generation	MEC 424F	3	1½	—	10
Computer-Aided Design	MEC 473F	3	—	1½	10
Thermal Environmental Design	MEC 420F	3	1½	—	10
Instrumentation Design	ELE 471F	3	1½	—	10
*Term 4S***					
Microscopic Thermodynamics	MEC 425S	3	1½	—	10
Manufacturing Analysis	MEC 475S	3	—	1½	10
Control Systems II	MEC 456S	3	—	1½	10
Numerical Analysis	CSC 481S	3	—	1½	10

** Technical Electives offered in the terms 3S and 4S are equally available to Third and Fourth Year students. Third Year students require the consent of the instructor if enrolling in a Fourth Year elective. With the approval of the Chairman of the Department, any other suitable course given by the Faculty of Applied Science and Engineering may be substituted as a Technical Elective. Department electives for which there is insufficient demand may be withdrawn.

Industrial Engineering

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E. E. Pickett, B.A.SC., M.A.

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J. R. Walter, M.A., M.B.A.

INDUSTRIAL ENGINEERING

Program 4

The modern view of Industrial Engineering is that of a field concerned with the analysis, design, improvement and operation of integrated systems of men, materials, equipment and information. This concept crystallized when it became clear that certain modern technical fields, including operational research, control theory, computer science, probability and statistics, systems theory, and human factors engineering constituted a body of knowledge particularly useful in the operation and management of modern business, industry and government.

As a logical outcome of this development, the course in Industrial Engineering was established in 1958 to provide graduates in engineering specializing in the theory and practice of these subjects. This specialization rests upon a substantial foundation in science and mathematics, in fundamental engineering disciplines including fluid mechanics, applied thermodynamics, electric science, mechanics of materials, materials science and automation, and in such subjects as economics, organizational structure, financial control and the behavioural sciences.

The curriculum in Industrial Engineering allows, but does not require, each student to take a Technical Elective outside the Department in each term in each of Second, Third and Fourth Year.

Students are urged to select their electives with care, in order to improve their general engineering education or their knowledge of an area in which they wish to specialize. A list of areas of concentration and corresponding recommended subjects is included in the Industrial Engineering Undergraduate Handbook, available from the Departmental Office.

For the First Year Curriculum see Engineering, page 24.

SECOND YEAR INDUSTRIAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Elements of Industrial Engineering I	IND 200F	2	—	2	8
Computers and Programming I	IND 202F	2	—	2	8
Calculus	MAT 293F	2	—	2	8
Probability	STA 291F	2	—	2	8
Technical Elective*					
Non-Technical Elective					8
Term 2S					
Elements of Industrial Engineering II	IND 201S	2	—	2	8
Computers and Programming II	IND 203S	2	—	2	8
Calculus and Differential Equations	MAT 294S	2	—	2	8
Statistics	STA 292S	2	—	2	8
Technical Elective*					
Non-Technical Elective					8

*See page 49

Technical Electives arranged and scheduled by the Department are:

Materials Science	MMS 222F	3	3	—	8
Introduction to Modern Physics	PHY 282F/S	3	—	—	8
Basic Classical and Modern Physics	PHY 283F	3	—	—	8
Mechanics of Materials	CIV 205S	2	3	—	8
Electrical Engineering	ELE 271S	3	1½	1	8

THIRD YEAR INDUSTRIAL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Accounting I	COM 390F	2	—	—	8
Numerical Methods I	CSC 381F	2	—	2	8
Operational Research I	IND 301F	2	—	2	8
Applied Statistical Analysis	IND 306F	2	—	2	8
Technical Elective*					
Open Elective					8

*See page 49

THIRD YEAR INDUSTRIAL ENGINEERING (CONTINUED)

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Operational Research II	IND 302S	2	—	2	8
Computers and Programming II□	IND 303S	2	—	2	8
Human Factors in Man-Machine Systems	IND 305S	2	3	—	8
Control Engineering	MEC 357S	2	1	1	8
Technical Elective*					
Open Elective					8

□For 1974–75 only. This subject will be replaced by another in 1975–76 and subsequent sessions.

*See page 49.

Technical Electives arranged and scheduled by the Department are:

Differential Equations	APM 391F	2	—	2	8
Accounting II	COM 391S	2	—	—	8
Numerical Methods II	CSC 386S	2	—	2	8
Industrial Relations	IND 304F	2	—	1	8
Introduction to Modern Physics	PHY 282F/S	3	—	—	8
Basic Classical and Modern Physics	PHY 283F	3	—	—	8
Electrical Engineering	ELE 271S	3	$1\tfrac{1}{2}$	1	8

FOURTH YEAR INDUSTRIAL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Free Elective					8
and five of:					
Organizational Behaviour	IND 412F	2	—	—	8
Fundamentals of Management Science	IND 413F	2	—	$1\tfrac{1}{2}$	8
Production Systems	IND 415F	2	—	$1\tfrac{1}{2}$	8
Stochastic Models	IND 417F	2	—	$1\tfrac{1}{2}$	8
System Simulation	IND 418F	2	—	$1\tfrac{1}{2}$	8
Management Information Systems	IND 421F	2	—	$1\tfrac{1}{2}$	8
Human Information Processing in Man-Machine Systems	IND 424F	2	3	—	8
Term Thesis†	IND 497F	—	6	—	8
Year Thesis†	IND 499	—	6	—	8
Other Technical Elective*					

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†At least one of IND 497F, IND 498S and IND 499 must be selected. If IND 499 is selected, then neither IND 497F nor IND 498S may be selected.

*See page 49.

FOURTH YEAR INDUSTRIAL ENGINEERING (CONTINUED)

Term 4S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Free Elective					8
and five of:					
Applications of Management Science	IND 414S	2	—	1½	8
Scheduling and Control	IND 416S	2	—	1½	8
Information and Optimization	IND 419S	2	—	1½	8
Mathematical Programming	IND 420S	2	—	1½	8
Human Performance in Man-Machine Systems	IND 423S	2	3	—	8
Dynamics of General Systems	IND 425S	2	—	1½	8
Term Thesis†	IND 498S	—	6	—	8
Year Thesis†	IND 499	—	6	—	8
Other Technical Elective*					

†At least one of IND 497F, IND 498S and IND 499 must be selected. If IND 499 is selected, then neither IND 497F nor IND 498S may be selected.

**Technical Electives*

One Technical Elective must be selected in each of Terms 2F, 2S, 3F, and 3S

One Technical Elective may be selected in each of Terms 4F and 4S. Each Technical Elective subject will be selected from one of four categories:

- —"basic science" subjects (List (a), below)
- —"applied science" subjects (List (b), below)
- — electives offered or sponsored by Industrial Engineering, and incorporated in the timetable for one or more terms
- — other acceptable technical subject, proposed by the student

Three of these Technical Electives must be used to satisfy "basic science" and "applied science" requirements, as outlined below. Additional information and guidance regarding other acceptable technical subjects may be found in the Industrial Engineering Undergraduate Student Handbook.

Students are reminded that all their course selections in any individual term and over the entire four years, are subject to approval by the Department on their merits as a program of studies.

At least one Technical Elective (taken in any term) must be selected from the following list:

List (a)	BIO 110	Principles of Biology
	CHM 240	Introductory Organic Chemistry
	PHY 215F	Geophysics

PHY 218	Applications of Physics in Medicine
PHY 282F/S	Introduction to Modern Physics
PHY 283F	Basic Classical and Modern Physics

At least two Technical Electives (taken in any two terms) must be selected from the following list:

List (b)	CIV 204F	Mechanics of Materials
	CIV 205S	Mechanics of Materials
	ELE 271S	Electrical Engineering
	MEC 321F	Thermodynamics
	MEC 327F	Heat Engineering
	MEC 341F	Fluid Mechanics
	MEC 349S	Transport Phenomena
	MEC 351F	Fluid Mechanics
	MMS 221F	Materials Science I
	MMS 222F	Materials Science
	MMS 223S	Materials Science
	MMS 226S	Inorganic Chemistry
	MMS 227S	Materials Science II

Engineering Science

FACULTY MEMBERS OF THE DIVISION

Chairman of the Division:

B. P. Stoicheff, B.A.SC., M.A., PH.D., F.R.S.C., *Professor of Physics*

Associate Chairman of the Division:

I. H. Rowe, M.A.SC., D.I.C.(IMP.COLL), PH.D.(LOND.), *Associate Professor of Electrical Engineering*

Members of the Division:

K. G. Balmain, B.A.SC., M.S.(ILL.), PH.D.(ILL.), *Professor of Electrical Engineering*

R. M. Farquhar, M.A., PH.D., F.R.S.C., *Professor and Associate Chairman of Physics*

W. D. Lakin, B.S.(M.I.T.), M.S.(CHICAGO), PH.D.(CHICAGO), *Associate Professor of Mathematics*

J. W. Rutter, B.A.SC., M.A., PH.D., *Professor of Metallurgy and Materials Science*

R. C. Tennyson, B.A.SC., M.A.SC., PH.D., *Associate Professor, Aerospace Studies*

O. Trass, B.S.E.(PRINC.), SC.D.(M.I.T.), *Professor of Chemical Engineering*

Z. G. Vranesic, M.A.SC., PH.D., *Associate Professor of Computer Science and Electrical Engineering*

C. A. Ward, B.SC.(TEX.) PH.D.(NORTHWEST.), *Associate Professor of Mechanical Engineering*

ENGINEERING SCIENCE

Program 5

The Engineering Science program is designed for students primarily interested in the application of science to modern technology, who wish to prepare themselves for careers in applied research, development or teaching. The undergraduate course provides excellent preparation for post-graduate work in a wide range of specialities in Engineering, Science and Mathematics, and the majority of graduates from this program do proceed to graduate study. Students who graduate from this program and do not continue thei studies are nevertheless well qualified to fill a variety of positions in industry, governmen and teaching.

The courses offered are of a high standard, so that only students with better-than-average ability in, and aptitude for, mathematics and science can expect to succeed in them. Fo this reason, admission is granted only to those who have achieved high standing in thei previous academic work, and continuation in the program requires a minimum of 55% at the end of the first term and 66% at the end of the second. A student who does not meet these requirements will be permitted to transfer into another engineering program of his choice, subject to the requirements and provisions of the General Regulations. A student who successfully completes the First Year in Engineering Science may also transfer into any other program in the Faculty. (Thereafter, transfers into other programs in the Faculty can normally be made, subject to some program adjustments.)

The curricula for the first two years of the program are common for all students, with some Technical Electives available in terms 1S and 2S. There are available eight carefully planned options † each of which provides a specialized preparation for a particular branch of applied science. In addition, students have the opportunity to select a program that does not conform to any one of the options, as outlined below.

For the First Year curriculum see Engineering Science, page 26.

SECOND YEAR ENGINEERING SCIENCE

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Numerical Methods	CSC 281F	2	—	1	7
Chemical Systems	CHE 209F	3	3	—	8½
Electric Circuits	ELE 250F	3	3	—	8½
Calculus III	MAT 295F	3	—	1	8
Elements of Physics III (Fields and Waves)	PHY 280F	3	1½	1	8
Non-Technical Elective					8
Term 2S					
Complex Variables	MAT 289S	3	—	1	8
Elements of Physics IV (Quantum Physics)	PHY 281S	2	1½	1	8
Probability and Statistics	STA 287S	3	—	1	8
Non-Technical Elective					8
and two of:					
Engineering Design*	APS 201S	—	—	6	8
Mechanics of Materials	CIV 203S	2	—	3	8
Computer Languages	CSC 280S	2	—	1	8
Materials Science	MMS 250S	2	1½	—	8

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†For further information about the Aerospace Option, see page 80.

*This course will be limited to 20 students.

Students entering third year may elect

(a) to enrol in one of the 8 options listed, or

(b) to select a program that does not conform to any one of the options.

In case (a), students may petition for meritorious substitutions on a basis of roughly equal weights, so that the modified program has approximately the same weight as the standard option. In case (b), the weight shall average approximately 48 units per term. In both cases, the selection of courses is subject to the constraints imposed by the current timetable, and by prerequisites. Courses may be chosen from among those offered to other options in Engineering Science; from among those listed in the Faculty Calendar that are offered in programs other than Engineering Science; or, with the approval of the offering department, from among those offered in other Faculties, provided that the total applied science and engineering content is not reduced.

All electives and substitutions require the approval of the Division.

THIRD YEAR ENGINEERING SCIENCE

Option 5a, Aerospace

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations I	APM 393F	3	—	—	8
Mechanics	AER 301F	3	—	1½	8
Fluid Mechanics	AER 305F	3	—	1½	8
Aerospace Laboratory I	AER 303F	—	3	—	8
Technical Elective					8
Open Elective					8
Term 3S					
Algebra	MAT 390S	3	—	—	8
Aerospace Laboratory II	AER 304S	—	3	—	7
Control Systems	ELE 358S	3	1½	1	9
Technical Elective					8
Open Elective					8
and one of:					
Mechanics of Structures	AER 302S	3	—	1½	8
Quantum and Statistical Mechanics	PHY 382S	3	—	—	8

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Option 5c, Chemical

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations I	APM 393F	3	—	—	8
Mass Transfer Operations I	CHE 312F	2	—	2	9
Thermodynamics and Kinetics I	CHE 303F	2	3	—	9
Chemical Engineering Problems and Laboratory I	CHE 315F	—	2	—	7
Technical Elective					8
Open Elective					8

Term 3S					
Algebra	MAT 390S	3	—	—	8
Thermodynamics and Kinetics II	CHE 304S	2	3	—	9
Mass Transfer Operations II	CHE 313S	2	—	1½	8
Chemical Engineering Problems and Laboratory II	CHE 316S	—	2	—	7
Polymer Chemistry	CHE 317S	3	—	—	8
Open Elective					8

Option 5cs, Computer Science

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Physical Electronics I	ELE 350F	2	¾	1	7
Electronic Circuits I	ELE 351F	2	1½	—	8
Computer Organization	ELE 353F	3	1½	1	10
System and Signal Analysis I	ELE 355F	3	—	1	8
Open Elective					8

Term 3S					
Algebra	MAT 390S	3	—	—	8
Operational Research	IND 331S	2	—	2	7
Electronic Circuits II	ELE 360S	3	1½	—	8
Introduction to the Theory of Computation	CSC 364S	2	—	1	7
System Software I	CSC 380S	2	6	—	10
Open Elective					8

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Option 5e, Electrical

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations I	APM 393F	3	—	—	8
Physical Electronics I	ELE 350F	2	$^3/_4$	1	7
Electronic Circuits I	ELE 351F	2	$1^1/_2$	—	8
System and Signal Analysis I	ELE 355F	3	—	1	8
Electromagnetic Fields	ELE 357F	3	$1^1/_2$	1	9
Open Elective					8

Term 3S					
Algebra	MAT 390S	3	—	—	8
Physical Electronics II	ELE 352S	2	$^3/_4$	1	7
Electronic Circuits II	ELE 354S	3	3	—	10
System and Signal Analysis II	ELE 356S	3	$1^1/_2$	—	8
Open Elective					8

and one of:

Quantum and Statistical Mechanics	PHY 382S	3	—	—	8
Digital Systems	ELE 314S	2	$1^1/_2$	—	6
Other Technical Elective					8

Option 5g, Geophysics

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Principles of Physical Geology†	GLG 120F	2	2	1	9
Physics of the Earth	PHY 442	2	—	—	7
Electromagnetic Fields	ELE 357F	3	$1^1/_2$	1	9
Technical Elective*					8
Open Elective					8

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†Students with credit for GLG 180S may substitute one of ELE 351F or PHY 334F.

*At least one of these Technical Electives must be a course offered by a Department of the Faculty of Applied Science and Engineering or by the Department of Geology. A list of recommended options is available from the Engineering Science Division Office or the Geophysics Laboratory.

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Algebra	MAT 390S	3	—	—	8
Principles of Historical Geology	GLG 122S	2	2	1	9
Physics of the Earth	PHY 442	2	—	—	7
Technical Elective*					8
Open Elective					8

and one of:

Elasticity and Fluid Mechanics	PHY 244S	2	—	—	8
Quantum and Statistical Mechanics	PHY 382S	3	—	—	8

Option 5m, Materials Science

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Physical Metallurgy	MMS 303F	3	3	—	8
Metallurgical Thermodynamics	MMS 306F	3	—	4	9
Introduction to Solid State Physics	PHY 334F	2	—	—	8
Structure of Materials	MMS 333F	—	2	2	8
Open Elective					8

Term 3S					
Algebra	MAT 390S	3	—	—	8
Physics of Metals	MMS 304S	3	3	—	8
Materials Science	MMS 307S	3	—	—	8
Technical Elective					8
Open Elective					8

and one of:

Applied Nuclear Chemistry	CHE 418S	2	—	1	7
Applied Nuclear Physics	PHY 336S	2	1	—	8
Ceramics	CHE 420S	2	—	1	7
Composite Materials	CHE 413S	2	—	1	7

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*At least one of these Technical Electives must be a course offered by a Department of the Faculty of Applied Science and Engineering or by the Department of Geology. A list of recommended options is available from the Engineering Science Division Office or the Geophysics Laboratory.

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Option 5nt, Nuclear and Thermal Power

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations I	APM 393F	3	—	—	8
Fluid Mechanics	MEC 354F	3	3	—	8
Statistical Thermodynamics	MEC 426F	3	1½	—	10
Heat Engineering	MEC 327F	2	3	—	8
Introduction to Nuclear Physics	PHY 335F	2	—	—	8
Open Elective					8
Term 3S					
Algebra	MAT 390S	3	—	—	8
Quantum and Statistical Mechanics	PHY 382S	3	—	—	8
Control Systems	ELE 358S	3	1½	1	9
Stress Analysis	MEC 315S	3	—	1	8
Open Elective					8
and one of:					
Applied Nuclear Chemistry	CHE 418S	2	—	1	7
Applied Nuclear Physics	PHY 336S	2	1	—	8
Other Technical Elective					8

Option 5p, Physics

Term 3F					
Differential Equations I	APM 393F	3	—	—	8
Mechanics	AER 301F	3	—	1½	8
Modern Physics Laboratory	PHY 326F	—	6	—	10
Open Elective					8
and one of:					
Physical Electronics I	ELE 350F	2	¾	1	7
Electronic Circuits I	ELE 351F	2	1½	—	8
Electromagnetic Fields	ELE 357F	3	1½	1	9
and one of:					
Molecular Biophysics*	PHY 332F	2	—	—	8
Introduction to Solid State Physics	PHY 334F	2	—	—	8
Introduction to Nuclear Physics	PHY 335F	2	—	—	8
Thermodynamics	PHY 353F	2	—	—	8

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*Not offered in 1974–75.

THIRD YEAR ENGINEERING SCIENCE (CONTINUED)

Term 3S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Algebra	MAT 390S	3	—	—	8
Quantum and Statistical Mechanics	PHY 382S	3	—	—	8
Open Elective					8
and one of:					
Physical Electronics II	ELE 352S	2	$\frac{3}{4}$	1	7
Stress Analysis	MEC 315S	3	—	1	8
Control Systems	ELE 358S	3	$1\frac{1}{2}$	1	9
and two of:					
Cellular Biophysics*	PHY 333S	2	—	—	8
Applied Nuclear Physics	PHY 336S	2	1	—	8
Elementary Particle Physics	PHY 337S	2	—	—	8
Modern Physics Laboratory	PHY 326S	—	6	—	10
Other Technical Elective					8

*Not offered in 1974/75

FOURTH YEAR ENGINEERING SCIENCE

Option 5a, Aerospace

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thesis	ESC 495	—	—	—	8
Differential Equations II	APM 491F	3	—	—	8
Free Elective					8
and one of:					
Engineering Design I	AER 406F	—	3	—	8
Aerospace Laboratory III	AER 408F	—	6	—	8
*and a selection of courses from groups A and B totalling approximately 16 units:					
Group A					
Aerodynamics	AER 401F	3	—	$1\frac{1}{2}$	9
Space Flight Dynamics	AER 402F	2	—	$1\frac{1}{2}$	8
Advanced Mechanics of Structures	AER 403F	2	—	$1\frac{1}{2}$	8

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*In the aggregate of terms 4F and 4S the student's program must include at least two courses from Group A. Courses in Groups A and B for which there is insufficient demand may be withdrawn.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
Group B					
Physics and Mechanics of Solids	AER 404F	3	—	$1^1/_2$	9
Fundamentals of Lasers, Plasmas and Energy	AER 415F	3	—	$1^1/_2$	9
Term 4S					
Thesis	ESC 495	—	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8
Free Elective					8
and one of:					
Engineering Design II	AER 407S	—	3	—	7
Aerospace Laboratory IV	AER 409S	—	6	—	7
*and a selection of courses from Groups A and B totalling approximately 16 units:					
Group A					
Gasdynamics	AER 410S	3	—	$1^1/_2$	9
Stability and Control of Aircraft	AER 411S	3	—	$1^1/_2$	9
Aeroelasticity	AER 412S	2	—	$1^1/_2$	8
Group B					
Acoustic Theory and Noise Control	AER 414S	2	$1^1/_2$	—	8
Technical Elective					8

Option 5c, Chemical

Term 4F					
Thesis	ESC 496	—	—	—	6
Differential Equations II	APM 491F	3	—	—	8
Rate Processes I	CHE 435F	3	—	—	9
Free Elective					8

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*In the aggregate of terms 4F and 4S the student's program must include at least two courses from Group A. Courses in Groups A and B for which there is insufficient demand may be withdrawn.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

		Lect.	*Lab.*	*Tut.*	*Wt.*
and two of:					
Chemical Plant Design	CHE 406F	—	—	6	9
Strategy of Product and Process Development	CHE 409F	2	3	—	9
Chemical Engineering Project	CHE 441F	—	6	—	9
Optimal Control of Chemical Systems	CHE 437F	3	—	$1^1/_2$	9
Term 4S					
Thesis	ESC 496	—	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8
Rate Processes II	CHE 436S	3	—	—	9
Free Elective					8
and two of:					
Topics in Applied Chemical Thermodynamics	CHE 404S	2	—	1	7
Selected Topics in Organic Chemistry	CHE 434S	2	—	1	7
Modelling and Simulation of Chemical Systems	CHE 440S	3	—	—	9
Option 5cs, Computer Science					
Term 4F					
Thesis	ESC 498F	—	—	—	8
Differential Equations II	APM 491F	3	—	—	8
Switching Theory	ELE 459F	2	—	1	7
Communication Systems I	ELE 453F	2	1	—	8
Operating Systems	CSC 468F	2	—	1	8
Free Elective					8
Term 4S					
Applied Functional Analysis	APM 446S	3	—	—	8
Computation Methods for Partial Differential Equations	CSC 446S	2	—	1	8
System Software II	CSC 480S	2	6	—	10
Techniques of Optimization	ELE 455S	3	—	1	8
Switching Circuits	ELE 432S	2	3	—	8
Free Elective					8

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Option 5e, Electrical

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations II	APM 491F	3	—	—	8
Free Elective					8
Select courses from the following to total approximately 48 units for the term:*					
Computer Organization	ELE 353F	3	1½	1	10
→ Network Theory	ELE 412F	3	—	2	8
Semiconductor Electronics	ELE 435F	2	1½	1	8
Computer Programming and Data Structure	ELE 440F	2	—	2	8
Techniques of System Theory	ELE 450F	2	1½	—	8
Electronic Circuits III	ELE 452F	2	3	—	8
Communication Systems I	ELE 453F	2	1	—	8
Switching Theory	ELE 459F	2	—	1	7
→ Fundamentals of Lasers, Plasmas and Energy	AER 415F	3	—	1½	9
Thesis[1]	ESC 495	—	—	—	8
Other Technical Elective					8

Term 4S					
Applied Functional Analysis	APM 446S	3	—	—	8
Free Elective					8
Thesis[1]	ESC 495	—	—	—	8
Thesis[1]	ESC 498S	—	—	—	8
Select courses from the following to total approximately 48 units for the term, at least 16 units of which must be from Electrical Engineering:*					

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*Courses for which there is insufficient demand may be withdrawn.

[1] Select either ESC 495 or ESC 498S, but not both.

[2] Limited enrolment.

[3] Courses joined by arrows cannot be taken together because of timetable conflicts.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

			Lect.	*Lab.*	*Tut.*	*W*
3	→ Nuclear Reactors and Instruments	CHE 429S	2	1½	1	8
	→ Operational Research	IND 331S	2	—	2	7
	→ Integrated Circuits	ELE 431S	2	3	—	8
3	Switching Circuits	ELE 432S	2	3	—	8
	→ Techniques of Optimization	ELE 455S	3	—	1	8
	Computer Organization	ELE 441S	2	3	—	8
	Biomedical Engineering[2]	ELE 445S	3	1½	—	8
3	→ Power Semiconductor Circuits	ELE 433S	2	3	—	8
	→ Communication Systems II	ELE 454S	2	3	—	8
	Microwave Electronics	ELE 457S	2	1½	1	8
	Other Technical Elective					8

Option 5g, Geophysics

Term 4F

Differential Equations II	APM 491F	3	—	—	8
Theory and Application of Geophysical Methods	PHY 443X	2	3	—	11
Time Series Analysis Laboratory	PHY 422F	—	6	—	8
Thesis	ESC 499	—	—	—	5
Technical Elective**					8
Free Elective					8

Term 4S

Applied Functional Analysis	APM 446S	3	—	—	8
Theory and Application of Geophysical Methods	PHY 443X	2	3	—	11
Thesis	ESC 499	—	—	—	5
Technical Elective I**					8
Technical Elective II**					8
Free Elective					8

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[2] Limited enrolment.

[3] Courses joined by arrows cannot be taken together because of timetable conflicts.

**At least one of the three Technical Electives must be a course offered by a Department of the Faculty of Applied Science and Engineering or by the Department of Geology. A list of recommended options is available from the Engineering Science Division Office or the Geophysics Laboratory.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

Option 5m, Materials Science

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thesis	ESC 495	—	—	—	8
Differential Equations II	APM 491F	3	—	—	8
Solid State Science	MMS 402F	3	3	1	9
Theory of Metallurgical Reactions	MMS 410F	2	—	2	8
Technical Elective					8
Free Elective					8
Term 4S					
Thesis	ESC 495	—	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8
Advanced Materials Science	MMS 411S	3	3	—	8
High Temperature Physical Chemistry	MMS 409S	2	—	2	8
Technical Elective					8
Free Elective					8

Option 5nt, Nuclear and Thermal Power

Term 4F					
Differential Equations II	APM 491F	3	—	—	8
Nuclear Reactor Fundamentals	CHE 442F	3	3	—	11
Energy Conversion	MEC 428F	3	3	—	11
Thesis	ESC 497	—	—	—	10
Free Elective					8
Term 4S					
Applied Functional Analysis	APM 446S	3	—	—	8
Neutron and Photon Transport	CHE 452S	3	—	2	10
Heat Transfer	MEC 433S	2	—	1	8
Thesis	ESC 497	—	—	—	6
Technical Elective					8
Free Elective					8

Option 5p, Physics

Term 4F					
Differential Equations II	APM 491F	3	—	—	8
Technical Elective *					8
Free Elective					8

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*These Technical Electives must all be courses offered by a department of the Faculty of Applied Science and Engineering.

FOURTH YEAR ENGINEERING SCIENCE (CONTINUED)

and three of:		*Lect.*	*Lab.*	*Tut.*	*Wt*
Quantum Physics Laboratory I	PHY 426F	—	6	—	8
Quantum Theory I	PHY 450C	2	—	—	8
Statistical Mechanics I	PHY 451C	2	—	—	8
Relativity Theory I	PHY 452C	2	—	—	8
Nuclear Physics I	PHY 453C	2	—	—	8
High Energy Physics I	PHY 454C	2	—	—	8
Solid State Physics I	PHY 455C	2	—	—	8
Modern Optics and Radiation I	PHY 456C	2	—	—	8
Group Theory and its Physical Applications I	PHY 457F	2	—	—	8
*Term 4S***					
Thesis	ESC 498S	—	—	—	8
Technical Elective 1*					8
Technical Elective 2*					8
and choose 3 courses from the following, at least 1 from Group A:					
Group A					
Quantum Theory II	PHY 450D	2	—	—	8
Statistical Mechanics II	PHY 451D	2	—	—	8
Relativity Theory II	PHY 452D	2	—	—	8
Applied Functional Analysis	APM 446S	3	—	—	8
Group B					
Quantum Physics Laboratory II	PHY 426S	—	6	—	8
Nuclear Physics II	PHY 453D	2	—	—	8
High Energy Physics II	PHY 454D	2	—	—	8
Solid State Physics II	PHY 455D	2	—	—	8
Modern Optics and Radiation II	PHY 456D	2	—	—	8
Group Theory and its Physical Applications II	PHY 458S	2	—	—	8

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*These Technical Electives must all be courses offered by a department of the Faculty of Applied Science and Engineering.

**If the Free Elective chosen in the Fall Term is a full year course, the portion offered in the Spring Term may be used to replace one of the Spring Term Electives.

Chemical Engineering and Applied Chemistry

STAFF OF THE DEPARTMENT

Professor and Chairman of the Department:
W. F. Graydon, M.A.SC., PH.D.(MINN.)

Professors and Assistant Chairmen of the Department:
M. E. Charles, B.SC.(LOND.), M.SC., PH.D.(ALTA.)
J. W. Smith, M.A.SC.(U.B.C.), PH.D.(LOND.)

Professors:
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M. Wayman, M.A., PH.D.
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R. T. Woodhams, M.SC.(U.W.O.), PH.D.(BROOKLYN)

Associate Professors:
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C. E. Chaffey, B.SC., PH.D.(McGILL)
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A. J. Szonyi, DIPL. ENG.(BUDAPEST), M.A.SC., PH.D.

Assistant Professors:
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J. S. Hewitt, B.SC.(QU.), M.SC., PH.D.(BIRM.)
Z. May, DIPL. ING. CHEM.(WARSAW)
Miss M. J. Phillips, B.A.SC., M.A.(BRYN MAWR), PH.D.(J.H.U.)
P. Y. Wang, B.SC., PH.D.(McGILL)

Lecturers:
C. C. Barnes, B.SC.(QU.)
J. Binkiewicz, DIPL. CHEM. ENG.(LWOW)
A. M. Rozeiu, DIPL. CHEM. ENG.(BUCHAREST)
R. B. Thompson, B.A.SC.

Special Lecturer:
Mrs. A. C. Kormendy, B.SC.(BUDAPEST), M.S.A.

CHEMICAL ENGINEERING

Program 6

Undergraduate study in the Department of Chemical Engineering and Applied Chemist is an excellent preparation for not only a career as a professional chemical engineer, b also for many careers in applied science. In recent years, many graduates from th Department have pursued such careers in addition to those entering the major chemic and petroleum industries.

The chemical engineer is concerned with the development and operation of process by means of which matter is chemically altered to a more useful form, and in the desig construction, operation and management of plant in which to effect such changes. I addition to such obviously chemical processes as those encountered in the petroleu refining and petro-chemical industry, a great variety of industrial processes involv chemistry and require the abilities of the chemical engineer.

In order to equip a student to start his professional career as a chemical engineer, t undergraduate course is intended to provide him with training in the principles of t major divisions of chemistry and chemical engineering, together with the essentials other engineering subjects. An important part of the course is the application of the principles to areas of major engineering interest.

Elective subjects available in the Department allow a particular emphasis to be achieved, for example, in one or more of the following areas: environmental chemistry and engineering, polymer science, wood chemistry, materials science, ceramics, medical engineering, energy production and conservation, analytical chemistry, fluid mechanics, nuclear power engineering, nuclear chemistry, biochemical engineering, optimal control, surface chemistry, combustion, pipeline transportation, separation processes and heat transfer. Specialist courses in other Departments or Faculties may also be selected, e.g. courses in biochemistry and microbiology for a program with a bio-chemical engineering emphasis. In this way, advantages may be taken of the resources within the University, and an individual student may arrange his program to suit his desires and career objectives.

In the final year, the topic chosen for the thesis allows the student additional specialization. The thesis serves as an introduction to research and the application of principles to topics of engineering interest, and its nature may vary widely depending on the interest of the staff and students. It may, for example, be concerned with an experimental laboratory investigation, the design of a process, or a computer study of a chemical system.

For the First Year curriculum see Engineering, Page 24.

SECOND YEAR CHEMICAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Physicochemical Principles in Chemical Engineering I	CHE 201F	2	—	—	5
Analytical Chemistry	CHE 204F	2	10½	—	14
Industrial Process Operations I	CHE 205F	3	—	2	9
Inorganic Chemistry I	CHE 217F	2	—	—	5
Calculus	MAT 280F	3	—	2	9
Non-Technical Elective					8
Term 2S					
Physicochemical Principles in Chemical Engineering II	CHE 202S	2	3	—	8
Industrial Process Operations II	CHE 206S	3	6	2	13
Organic Chemistry I	CHE 207S	3	3	—	10
Applied Math in Chemical Engineering	CHE 208S	2	—	1	6
Inorganic Chemistry II	CHE 218S	2	—	—	5
Non-Technical Elective					8

All students must complete Practical Experience APS 299 during their undergraduate program. This is normally satisfied during the summer periods between the Second and Third, or Third and Fourth Years.

THIRD YEAR CHEMICAL ENGINEERING (CONTINUED)

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thermodynamics and Kinetics I	CHE 301F	3	6	2	14
Applied Mathematics in Chemical Engineering	CHE 305F	2	—	1	6
Organic Chemistry II	CHE 309F	3	9	—	14
Mass Transfer Operations I	CHE 310F	2	—	2	8
Open Elective					8
Term 3S					
Thermodynamics and Kinetics II	CHE 302S	3	6	2	14
Mass Transfer Operations II	CHE 311S	2	$4\frac{1}{2}$	1	11
Fluid Mechanics	CHE 314S	3	$1\frac{1}{2}$	1	10
Chemical Engineering Topics	CHE 318S	3	—	—	6
Open Elective					8

All students must take a one-term basic science course in either the Third or Fourt Year. Normally this course is selected from courses offered by the Department c Chemistry, Physics, Biochemistry, Mathematics, Biology or Geology in the Faculty c Arts and Science; courses offered in other departments may also be acceptable. In Thir Year a basic science course can be selected as an Open Elective.

Students are reminded of the necessity to complete the Practical Experience, APS 299.

FOURTH YEAR CHEMICAL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Thesis, Public Dissertation and Seminar	CHE 499	—	8	2	10
Free Elective					8
two of: *					
Chemical Engineering Thermodynamics	CHE 402F	2	—	1	7
Energy, Environment and Resources	CHE 454F	2	—	1	7
Topics in Heat Transfer	CHE 455F	2	—	1	7
Pulp and Paper Chemistry, Technology and Engineering	CHE 417F	2	—	1	7
Chemical Reactors	CHE 432F	2	—	1	7
Industrial Biological Processes	CHE 448F	2	—	1	7
Economic Evaluation in the Process Industries	CHE 456F	2	—	1	7

FOURTH YEAR CHEMICAL ENGINEERING (CONTINUED)

two of:*		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Chemical Plant Design	CHE 405F	—	—	6	7
Process Modelling and Simulation	CHE 407F	2	—	3	7
Strategy of Product and Process Development	CHE 408F	2	3	—	7
Advanced Separation Processes	CHE 410F	2	—	1½	7
Atmospheric Dispersion	CHE 446F	2	—	1½	7
Pipeline Transportation	CHE 412F	2	—	1½	7
Introduction to Nuclear Engineering	CHE 427F	2	—	1	7
Term 4S					
Thesis, Public Dissertation and Seminar	CHE 499	—	12	3	17
Free Elective					8
three of:*					
Applied Nuclear Chemistry	CHE 418S	2	—	1	7
Ceramics	CHE 420S	2	—	1	7
Momentum, Heat & Mass Transfer	CHE 457S	2	—	1	7
Environmental Engineering	CHE 423S	2	—	1	7
Instrumental Methods	CHE 425S	2	—	1	7
Advanced Inorganic Chemistry	CHE 426S	2	—	1	7
Optimal Control	CHE 431S	2	—	1	7
Topics in Applied Chemical Thermodynamics	CHE 404S	2	—	1	7
Electrochemical Energy	CHE 453S	2	—	1	7
Selected Topics in Organic Chemistry	CHE 434S	2	—	1	7
Plastics Engineering	CHE 444S	2	—	1	7
Petroleum Engineering	CHE 445S	2	—	1	7
Catalysis	CHE 447S	2	—	1	7
Composite Materials	CHE 413S	2	—	1	7
Nuclear Chemical Engineering	CHE 449S	2	—	1	7
Other Technical Elective					7

*Students are reminded that they must take a one-term basic science course before graduation. If this requirement has not been satisfied in the Third Year, then a basic science course may be selected as either a Technical Elective or a Free Elective in the Fourth Year. Any elective for which too few students register may be withdrawn.

Electrical Engineering

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ELECTRICAL ENGINEERING

Program 7

Electrical engineers are concerned with all forms of electrical phenomena and applications. The early applications of electricity – the generation, transmission and utilization of electrical energy and the communication of information – are still important, but have been or are likely to be transformed by new applications and potential applications such as magneto-hydrodynamic generation, transmission by superconductors, and satellite communication. In addition, there are completely new fields of application which were not even envisaged a few years ago. There is a growing demand for complex electrical measuring and control equipment for a wide variety of non-electrical processes, and for electronic computers capable of the rapid processing of large volumes of information and the solving of increasingly complex problems.

Within any of these areas, the electrical engineer may be engaged in research, development, design, manufacture, operation or management. He may have to assist other engineers and scientists in widely differing fields by supplying them with techniques or insights unfamiliar to them, as for example, in the developing field of bio-medical engineering, or he may have to coordinate the application of many technologies in a single project.

It is obvious then, from the wide range of his possible involvement, that the electrical engineer needs a professional education of great breadth and depth. In the undergraduate course, stress is laid on building a solid foundation of engineering science and design technique. The time limitation requires that only material which is essential can be included; much that might be immediately helpful must be omitted to make room for that which will be relevant for several years. In addition, the undergraduate is given the opportunity of studying non-technical subjects of his own choice.

The electrical engineer makes extensive use of mathematical techniques and concepts; mathematics is thus of the utmost importance and a large portion of the course is devoted to it. Fundamental subjects such as mechanics, electrical physics, chemistry and thermodynamics get considerable attention in the early years. The basic electrical engineering subjects (electromagnetic field theory, electronics, machine principles and circuit theory) follow these, with expansion and specialization in the final year. In the final year, students freely select their whole program from a wide range of elective subjects. The undergraduate course is intended to provide a base on which to build the continuing education that is needed throughout the Engineer's career.

Electrical engineering is characterized by the relatively large proportion of its graduates who proceed to post-graduate study to get advanced training in a particular area. Information on this may be obtained from the calendar and other publications of the School of Graduate Studies.

For the First Year curriculum see Engineering, page 24.

SECOND YEAR ELECTRICAL ENGINEERING

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations	MAT 290F	3	—	2	8
Complex Variable and Vector Calculus	ELE 200F	3	—	2	8
Circuit Theory I	ELE 210F	3	1½	1	9
Materials Science I	MMS 221F	3	1½	—	8
Dynamics	MEC 205F	2	—	1	7
Non-Technical Elective					8
Term 2S					
Numerical and Probabilistic Methods	ELE 201S	3	—	2	8
Electric and Magnetic Fields	ELE 221S	3	—	2	8
Circuit Theory II	ELE 211S	3	1½	1	9
Materials Science II	MMS 227S	2	1½	—	7
Electronic Circuits A	ELE 231S	2	1½	1	8
Non-Technical Elective					8

THIRD YEAR ELECTRICAL ENGINEERING

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Electromechanical Systems I	ELE 312F	3	1½	1	9
Systems and Signal Analysis A	ELE 310F	3	—	2	9
Physical Electronics A	ELE 335F	2	¾	¾	6
Fields and Waves	ELE 320F	2	1½	1	8
Thermodynamics and Statistical Mechanics	PHY 384F	3	—	1	8
Open Elective					8
Term 3S					
Digital Systems	ELE 314S	2	1½	—	6
Electromechanical Systems II	ELE 313S	3	1½	1	9
System and Signal Analysis B	ELE 311S	3	1½	1	9
Physical Electronics B	ELE 336S	2	—	1½	6
Electronic Circuits B	ELE 331S	3	3	—	10
Open Elective					8

FOURTH YEAR ELECTRICAL ENGINEERING

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Free Elective					8
Select additional courses from the following to total 48 units[2] for the term including at least 32 units from Group A.*					
Group A					
Thesis[4]	ELE 498F	—	—	—	8
Thesis[4]	ELE 496F	—	—	—	16
Communication Systems A	ELE 416F	2	3	—	8
→ Switching Theory	ELE 405F	2	—	2	8
→ Electromagnetic Theory	ELE 420F	2	—	2	8
Control Systems I	ELE 410F	2	1½	1	8
→ Electromechanical Systems III	ELE 419F	2	1½	1	8
→ Applied Optics	ELE 448F	2	1½	1	8
Electronic Circuits C	ELE 430F	2	3	—	8
Computer Programming and Data Structures	ELE 440F	2	—	2	8
→ Semiconductor Electronics	ELE 435F	2	1½	1	8
→ Power System Analysis	ELE 413F	2	1½	1	8
→ Network Theory	ELE 412F	3	—	2	8
Group B					
→ Engineering as a Profession[5]	ELE 449F	2	—	—	8
Other Technical Elective[3]		—	—	—	8

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[1] Courses joined by arrows cannot be taken together because of timetable conflicts.

[2] For students proceeding at a normal rate, see page 170 for minimum and maximum loadings.

[3] Any Third or Fourth Year courses offered by departments of the Faculty of Applied Science and Engineering and listed in the programs of this calendar are acceptable. Where enrolments are limited (as noted in the calendar) the student is responsible for obtaining the necessary approval. Other technical or physical science courses require the approval of the teaching department offering the course and the Department of Electrical Engineering.

[4] A thesis is compulsory. The minimum weighting is 8 for the year. The maximum permitted is 16 for the year. Thus the selections allowed are any one of ELE 496F, 497S, 498F or 499S; or both of ELE 498F and ELE 499S. The selection must be approved by the student's thesis supervisor.

[5] Limited enrolment.

*Departmental electives for which there is insufficient demand may be withdrawn.

FOURTH YEAR ELECTRICAL ENGINEERING (CONTINUED)

Term 4S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Free Elective					8
Select additional courses from the following to total 48 units[2] including at least 32 units from Group A.*					
Group A					
Thesis[4]	ELE 499S	—	—	—	8
Thesis[4]	ELE 497S	—	—	—	6
Control Systems II	ELE 411S	2	1½	1	8
➤ Computer Organization	ELE 441S	2	3	—	8
➤ Power Semiconductor Circuits	ELE 433S	2	3	—	8
➤ Communication Systems II	ELE 454S	2	3	—	8
➤ Biomedical Engineering[5]	ELE 445S	3	1½	—	8
➤ Quantum Electronics	ELE 437S	3	1½	—	8
➤ Illumination[5]	ELE 447S	3	1½	—	8
➤ Microwave Electronics	ELE 457S	2	1½	1	8
➤ Power System Control	ELE 414S	2	1½	1	8
Integrated Circuits	ELE 431S	2	3	—	8
➤ Switching Circuits	ELE 432S	2	3	—	8
➤ Microwaves and Optics	ELE 421S	2	1½	1	8
Group B					
➤ Nuclear Reactors and Instruments	CHE 429S	2	1½	1	8
➤ Acoustic Theory and Noise Control	AER 414S	2	1½	—	8
Other Technical Elective[3]		—	—	—	8

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[1] Courses joined by arrows cannot be taken together because of timetable conflicts.

[2] For students proceeding at a normal rate: see page 170 for minimum and maximum loadings.

[3] Any Third or Fourth Year courses offered by departments of the Faculty of Applied Science and Engineering and listed in the programs of this calendar are acceptable. Where enrolments are limited (as noted in the calendar) the student is responsible for obtaining the necessary approval. Other technical or physical science courses require the approval of the teaching department offering the course and the Department of Electrical Engineering.

[4] A thesis is compulsory. The minimum weighting is 8 for the year. The maximum permitted is 16 for the year. Thus the selections allowed are any one of ELE 496F, 497S, 498F or 499S; or both of ELE 498F and ELE 499S. The selection must be approved by the student's thesis supervisor.

[5] Limited enrolment.

*Departmental electives for which there is insufficient demand may be withdrawn.

Metallurgy and Materials Science

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METALLURGY AND MATERIALS SCIENCE

Program 8

In terms of its diversity and scale of operation, the metallurgical industry in Canada ranks among the world's outstanding industrial achievements; it is also responsible for a considerable portion of the country's economy. In this field of endeavour, the metallurgist fulfils an important and useful role in the extraction, fabrication and application of metals and their alloys.

In recent years the needs of modern society have made increasingly severe demands upon materials required for various types of construction. This has led to the development of the new field of materials science which applies many of the techniques of the metallurgist and others to the study of a wide spectrum of materials. For example the practical application of nuclear energy is limited only by the availability and costs of materials which can withstand in-pile operation; advances in communications depend upon the development of materials having special electrical and magnetic properties; aerospace travel requires materials capable of withstanding extremes of heat, cold and pressure.

The program is perhaps unique in the Faculty in that it draws heavily on both physics and chemistry. It should, therefore, appeal to students with an interest in either of these basic scientific fields. The program is designed to place primary emphasis upon the fundamental principles of metallurgy, materials science and engineering rather than on the operative conditions of industrial practice. In the Fourth Year, each student prepares a thesis on an experimental problem which, where possible, is related to research in progress within the Department. A wide range of electives in the Third and Fourth Year culminates in a final Term 4S which consists entirely of material chosen by the student in consultation with an assigned staff tutor. In this manner, the student may elect courses which emphasize either the industrial or the research aspects of metallurgy, materials science and engineering.

The Department is equipped with modern facilities for the study of the structure and properties of materials. This equipment includes mass spectrometers, x-ray diffraction units, an electron beam microprobe analyzer, electron microscopes, several optical metallographs, and materials preparation and testing equipment. Facilities for mineral processing and for the production and measurement of high temperatures and high vacuum are also available.

For the First Year curriculum see Engineering, page 24.

SECOND YEAR METALLURGY AND MATERIALS SCIENCE

Term 2F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Calculus	MAT 293F	2	—	2	8
Introduction to Modern Physics	PHY 282F	3	—	1	7
Mechanics of Materials	CIV 204F	3	$1\frac{1}{2}$	—	8
Structure of Materials and Metallography	MMS 201F	2	3	1	8
Metallurgical Thermodynamics I	MMS 202F	2	—	3	8
Non-Technical Elective					8

SECOND YEAR METALLURGY AND MATERIALS SCIENCE (CONTINUED)

Term 2S		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Calculus and Differential Equations	MAT 294S	2	—	2	8
Probability and Statistics	STA 282S	2	—	2	8
Metallurgical Thermodynamics II	MMS 203S	2	—	3	8
Materials Chemistry	MMS 204S	2	3	2	9
Materials Science	MMS 205S	2	—	2	7
Non-Technical Elective					8
Practical Experience	APS 299	—	—	—	—

THIRD YEAR METALLURGY AND MATERIALS SCIENCE

Term 3F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Differential Equations	APM 391F	2	—	2	8
Mineral Processing I	MMS 301F	2	3	1	8
Electrochemical and Kinetic Processes	MMS 302F	2	—	4	8
Physical Metallurgy	MMS 303F	3	3	—	8
Open Elective					8
and one Materials Science elective[1,2]					
Ceramic Materials	MMS 308F	2	—	2	8
Materials Science Laboratory	MMS 331F	—	3	1	7
Physical Electronics A	ELE 335F	2	3/4	3/4	6
Physical Electronics I	ELE 350F	2	—	1 1/2	7
Introduction to Solid State Physics	PHY 334F	2	—	—	8
Term 3S					
Numerical Methods	CSC 236S	2	—	1	7
Transport Phenomena	MEC 349S	3	1 1/2	1 1/2	8
Physics of Metals	MMS 304S	3	3	—	8
Extractive Metallurgy I	MMS 305S	4	3	—	9
Open Elective					8
and one of:[1,2]					
Extractive Metallurgy Laboratory	MMS 332S	—	3	1	7
Applied Nuclear Chemistry	CHE 418S	2	—	1	7
Advanced Engineering Materials	CIV 414S	3	—	2	8

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[1] With the approval of the Chairman of the Department, any other suitable technical course may be substituted as an elective.

[2] The student must consult with his assigned staff tutor before choosing Technical Electives. Departmental electives for which there is insufficient demand may be withdrawn.

FOURTH YEAR METALLURGY AND MATERIALS SCIENCE

Term 4F		*Lect.*	*Lab.*	*Tut.*	*Wt.*
Electrical Systems	ELE 470F	3	3	—	9
Extractive Metallurgy II	MMS 401F	3	3	1	9
Solid State Science	MMS 402F	3	3	1	9
Thesis	MMS 499	—	6	—	6
Free Elective					8
and one of: [1,2]					
Hydrometallurgy	MMS 413F	2	1½	1	8
Mineral Engineering	MMS 417F	2	1½	1	8
Powder Metallurgy	MMS 431F	2	—	1	8
Introduction to Nuclear Engineering	CHE 427F	2	—	1	7
Operational Research I	IND 301F	2	—	2	8
Term 4S					
Thesis	MMS 499	—	12	—	12
Free Elective					8
two of: [2]					
Advanced Chemical Metallurgy	MMS 406S	1	—	3	7
Metallurgical Systems Analysis	MMS 407S	2	—	1	7
High Temperature Physical Chemistry	MMS 409S	2	—	2	8
Mineral Processing II	MMS 412S	2	1½	—	7
Operational Research II	IND 302S	2	—	2	8
and two of: [2]					
Materials Engineering	MMS 408S	3	—	—	7
Advanced Materials Science	MMS 411S	3	3	—	8
Nuclear Materials	MMS 416S	3	—	1	7
Composite Materials	CHE 413S	2	—	1	7

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[1] With the approval of the Chairman of the Department, any other suitable technical course may be substituted as an elective.

[2] The student must consult with his assigned staff tutor before choosing Technical Electives. Departmental electives for which there is insufficient demand may be withdrawn.

Aerospace Studies

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Associate Professors:

P. C. Hughes, B.A.SC., M.A.SC., PH.D.
G. W. Johnston, B.A.SC., M.A.SC., PH.D.
R. M. Measures, B.SC., A.R.C.S., D.I.C.PH.D.(LOND.)
L. D. Reid, B.A.SC., M.A.SC., PH.D.
P. A. Sullivan, B.E., M.E.(N.S.W.), D.I.D., PH.D.(LOND.)
R. D. Tennyson, B.A.SC., M.A.SC., PH.D.

Assistant Professors:

J. W. Lock, B.A.SC., M.A.SC., PH.D.
P. C. Stangeby, B.SC., M.SC., DIPL. PLASMA SCI., D.PHIL.(OXON)

Laboratory Supervisor:

A. A. Haasz, B.A.SC., M.A.SC.

AEROSPACE SCIENCE AND ENGINEERING

The University of Toronto offers a broad and coherent program of studies in the aerospace sciences and engineering. It is designed to prepare its graduates for work in a variety of areas including civil air transportation, design and development of new aircraft, spacecraft and air cushion vehicles, and fundamental research in many of the relevant underlying areas of science. Future Canadian needs for air and surface transportation, satellite communications and survey. Satellites are significant factors in determining the content of the courses and the research projects undertaken.

The courses of study available comprise a basic four year program leading to the B.A.Sc. degree, an additional year leading to the M.Eng. or M.A.Sc. degree, and a subsequent Doctoral program. The undergraduate (Bachelor's) program consists of four years in Engineering Science (Option 5a), and the post-graduate programs are taken in the Department of Aerospace Science and Engineering of the School of Graduate Studies.

(i) *Undergraduate Program.* The details of the undergraduate program are given in this Calendar (page 51) and are seen to consist mainly of intensive studies in the fundamentals of mathematics, physics, and engineering sciences correlated with design and synthesis activities illustrative of modern Engineering practice in the aerospace field. In the final two years, the program is oriented to the special needs of the aerospace field, and includes some highly specialized courses. The aerospace-related subjects in these two years are taught by the faculty of the Institute for Aerospace Studies. Graduates of this program are able to fill a variety of positions in education, industry and government, but the fifth year (see below) is recommended for those who wish to improve their qualifications for employment as aerospace engineers.

(ii) *Graduate Program.* If the student's academic record in the undergraduate program meets the requirements for admission to the School of Graduate Studies, he may pursue during a fifth year a program as a candidate for the M.A.Sc. or M.Eng. degree in the (graduate) Department of Aerospace Science and Engineering. Details of entrance regulations and courses of study are given in the Calendar of the School of Graduate Studies. The facilities of the Institute for Aerospace Studies are available to the student for research or project work. For details of research fields, assistantships, scholarships and demonstratorships, students should consult the Secretary of the graduate department.

It should be noted that a student who has graduated in another branch of Engineering, or in science or mathematics, and who desires to qualify as an Aerospace Engineer may be admitted to the graduate program. In that case the courses leading to the M.A.Sc. or M.Eng. degree will be arranged on an individual basis so that any deficiencies in undergraduate training are made up.

The facilities of the Institute are available for further graduate study and research leading to the Ph.D. degree.

Outline of Courses

On the following pages are brief outlines of the courses prescribed for students in the Faculty of Applied Science and Engineering, listed in alphabetical order of the prefixes (AER, CIV, etc.) which identify the teaching department. The suffix following the course number indicates the term in which the course is given; the second line of the description shows the program and year in which the course is prescribed, and the number of hours of lectures, laboratory and tutorial work per week, and the weight units assigned to the course. For example:

MEC 205F Dynamics
II–7 2 – 1 7

indicates a fall-term course offered by the Department of Mechanical Engineering for students in Second Year Electrical Engineering. The course consists of 2 hours lectures, no laboratory, and 1 hour tutorial per week, and has a weight of seven units.

Many course descriptions include a statement of prerequisites and corequisites for the information of students, but the absence of such a statement does not imply that the course does not have prerequisites.

The recommendations for textbooks should be considered as tentative only, and subject to change. Students should therefore not purchase textbooks until they have been in attendance in the course, unless informed otherwise by their department.

*Interpretation of suffixes to course numbers:**

F: A first-term (Fall) course.
S: A second-term (Spring) course.
F/S: Indicates that the course given in the first term is repeated in the second term; a student may take one or the other, but not both.
C: The first half of a full year course taken in the Faculty of Arts and Science; Engineering students will be evaluated at the end of the first term. (Both parts of the course must be taken.)
D: The second half of the above. (Both parts of the course must be taken.)

*The absence of a suffix indicates that the course continues over both terms.

X: When added to a course offered in the Faculty of Arts and Science, signifies that a laboratory course with a different number has been added for Engineering students.
Y: A half-course in the Faculty of Arts and Science given over a full year.

DEPARTMENT OF AEROSPACE SCIENCE AND ENGINEERING

AER 301F MECHANICS

III – 5a, 5p 3 – 1½ 8

Reference frames in relative translation and rotation, vector and matrix formulations. Dynamics of a single particle and of systems of particles. Lagrange's equations. Rigid body kinematics and dynamics, Lagrangian approach to vibrations of complex systems. Special topics by request. Primary Reference: class notes. Reference Books: Greenwood, *Principles of Dynamics*; Page, *Introduction to Theoretical Physics*, *Principles of Mechanics*. *P. A. Sullivan*

AER 302S MECHANICS OF STRUCTURES

III – 5a (elective) 3 – 1½ 8

Basic theorems and principles in the theory of structures (strain energy, virtual displacements, minimum total potential energy). General theory of bending of beams (unsymmetrical bending, thin walled structures, shear flow in multiflanged beams, open and closed sections). General theory of torsion (thin walled structures, multicell structures, shear centre). Theory of elastic instability (buckling of slender elastic struts, flat and curved plates, shells). Plane stress problems (Airy and Prandtl stress functions). Application of theory to the design of aerospace structures is given in tutorials. *R. C. Tennyson*

AER 303F AEROSPACE LABORATORY I

III –5a – 3 – 8

Prepared experiments and/or laboratory projects in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required. *A. A. Haasz*

AER 304S AEROSPACE LABORATORY II

III – 5a – 3 – 7

Prepared experiments and/or laboratory projects in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility and analysis and design, construction and assembly of apparatus (prototype), and experimentation (or testing prototype). The submission of a formal project report is required. *A. A. Haasz*

AER 305F FLUID MECHANICS

III – 5a 3 – 1½ 8

Introductory concepts and idealizations of real fluids; theory of incompressible inviscid flow including potential flow, vorticity, complex potential, conformal transformations; viscous fluid flow, turbulence; Navier-Stokes equations; introduction to boundary layer theory. Reference Books: Prandtle and Tietjens, *Fundamentals of Hydro and Aeromechanics*; Streeter, *Fluid Dynamics*; Laamb, *Hydrodynamics*. *H. S. Ribner*

AER 401F AERODYNAMICS

IV – 5a (elective) 3 – 1½ 9

Thin airfoil theory, vortex theory, finite wings, compressibility effects, supersonic and hypersonic wing theory. Propulsion: Momentum theorem, propeller actuator disc analysis, blade element approach, axial compressors and turbines. Air cushion vehicles. Aircraft performance; drag, basic performance parameters, range, turning flight take-off. Illustrative design methodology. Basic concepts in static stability and control. Reference Books: Kuethe and Schetzer, *Foundations of Aerodynamics*; McCormick. *Aerodynamics of V/STOL Flight*. *J. B. French*

AER 402F SPACE FLIGHT DYNAMICS

IV – 5a (elective) 2 – 1½ 8

Kepler's problem; time of flight; Lambert's problem; trajectory design; coordinate systems and orbital elements; orbit determination; impulse thrust approximation; patchec conic approximation; manoeuvres; three-body problem; lunar trajectories; rigid body ir torque-free motion; gravity-gradient potential; librations of rigid body in circular orbit spinning rigid body in circular orbit; dissipation effects; effects of structural flexibility. *P. C. Hughe*

AER 403F ADVANCED MECHANICS OF STRUCTURES

IV – 5a (elective) 2 – 1½

Matrix analysis of redundant structures including the force and displacement methods Flexibility and stiffness matrices for structural elements derived, effects of therma strains and structural cutouts. Automated techniques for determining redundant members. The finite element approach, derived, and applied to plates and shells. The methoc of individual displacements, with solutions given for buckling loads, natural frequencie and stress distributions in structures. Application of analytical methods to the design o aerospace structures is given in tutorials. Reference Books: J. S. Przemienicki, *Theory o Matrix Structural Analysis*, McGraw-Hill, New york (1968); Zienkiewicz, O. C. anc Cheung, Y. K., *The Finite Element Method in Structural and Continuum Mechanics*, McGraw-Hill, London (1967). *R. C. Tennysor*

AER 404F PHYSICS AND MECHANICS OF SOLIDS

IV – 5a (elective) 3 – 1½ 9

Atomic structure, molecular bonding, lattice theory, structural imperfections, composite materials. Elasticity, viscosity, plasticity, strength of materials, fracture, fatigue, radiation damage, corrosion. Thermal expansion, heat capacity, diffusivity, thermoelasticity, Metals, insulators, semiconductors, electrical conductivities, dielectric property. Optical properties.

AER 406F ENGINEERING DESIGN I

IV – 5a (elective) – 3 – 8

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Emphasis is placed on projects permitting students to independently carry out the preliminary and innovative stages of design. Recent design projects include spacecraft design, vehicle simulator design, and air cushion vehicle design. Drawings and reports are prepared as required. *G. W. Johnston*

AER 407S ENGINEERING DESIGN II

IV – 5a (elective) – 3 – 7

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Emphasis is placed on projects permitting students to independently carry out the preliminary and innovative stages of design. Recent design projects include spacecraft design, vehicle simulator design, and air cushion vehicle design. Drawings and reports are prepared as required. *G. W. Johnston*

AER 408F AEROSPACE LABORATORY III

IV – 5a (elective) – 6 – 8

Prepared experiments and/or laboratory projects in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required. *A. A. Haasz*

AER 409S AEROSPACE LABORATORY IV

IV – 5a (elective) – 6 – 7

Prepared experiments and/or laboratory projects in subject areas associated with the Aerospace curriculum. The projects involve application of materials in various courses to the solution of Engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required.

A. A. Haasz

AER 410S GASDYNAMICS

IV – 5a (elective) 3 – 1½ 9

Fundamental phenomena occurring in compressible flows are treated. Basic thermodynamics and the equations of inviscid and viscous compressible flows are reviewed. Compressible flows in nozzles, diffusers, and ducts with viscous and diabetic effects, and shock and expansion waves in both steady and nonstationary flows including high temperature effects that cause departures from the perfect gas law and equilibrium, are examples in a tutorial laboratory. Reference Books: Lipemann and Roshko, *Elements of Gasdynamics*; Shapiro, *Dynamics and Thermodynamics of Compressible Fluid Flow*. (Prerequisite: AER 305S). *J. W. Locke*

AER 411S STABILITY AND CONTROL OF AIRCRAFT

IV – 5a (elective) 3 – 1½ 9

Introduction to the dynamic stability and control-response of aircraft. Equations of motion for small perturbations from steady flight; longitudinal stability; lateral stability; response to throttle, elevator, aileron, rudder; flight in turbulence. Reference Book: Etkin, *Dynamics of Flight-Stability and Control*. Prerequisite: AER 401F). *L. D. Reid*

AER 412S AEROELASTICITY

IV – 5a (elective) 2 – 1½ 8

Static aeroeleastic phenomena are studied, including divergence of slender wings, the effect of low aspect ratio, sweep and wing-aileron interaction. Various methods of solution are considered such as closed form, matrix format iteration and the Rayleigh-Ritz approach. A study of vibration and flutter of wings and control surfaces is presented with particular emphasis on those parameters which affect flutter speed. Reference Books: Fung, Y. C., *An Introduction to the Theory of Aeroelasticity*, Dover Paperback Publications (1969). *J. J. Glaser*

AER 414S ACOUSTIC THEORY AND NOISE CONTROL

IV – 5a, 7 (elective) 2 1½ – 8

Basic acoustic theory including acoustic plane waves in infinite medium, real fluid effects, radiation of sound in three dimensions, sound propagation in ducts, and architectural acoustics. Noise control theory including transmission and radiation of sound by solid structures, mufflers, filters, resonators, enclosures and porous lining, sound propagation outdoors, subjective response to noise and industrial sources.

H. S. Ribner, G. W. Johnston

AER 415F FUNDAMENTALS OF LASERS, PLASMAS AND ENERGY

IV – 5a, 5e (elective) 3 – 1½ 9

Energy – world situation, energy conversion schemes: solar, fusion, fission; review of atomic physics and Maxwell's equations, fundamentals of spectroscopy, introduction of plasma physics, plasma spectroscopy, lasers and their properties, laser diagnostics of plasmas, thermonuclear fusion plasmas and laser induce fusion. *R. M. Measures*

DEPARTMENT OF APPLIED MATHEMATICS

APM 391F DIFFERENTIAL EQUATIONS

III – 8; III – 4 (elective) 2 – 2 8

First and second order ordinary differential equations, operational methods, variation of parameters, solution in series. Bessel and Legendre functions, the Laplace transform. (Prerequisite: MAT 294S) *F. V. Atkinson*

APM 393F DIFFERENTIAL EQUATIONS I

III – 5 3 – – 8

Ordinary differential equations. Existence and uniqueness theorems. General theory of linear homogeneous systems. Asymptotic behaviour and stability. Linear non-homogeneous systems. Series solution of linear equations with analytic coefficients, Bessel and Legendre equations. Boundary value problems. Sturm-Liouville systems. Green's functions. Eigenvalue problems. Stability of non-linear plane autonomous systems. *D. K. Sen*

APM 446S APPLIED FUNCTIONAL ANALYSIS

IV – 5a, c, cs, e, g, m, nt; 5p (elective) 3 – – 8

Hilbert and Banach spaces, with applications, dual spaces, linear operators, elements of spectral theory, extremal problems, integral and functional equations. *W. D. Lakin*

APM 491F DIFFERENTIAL EQUATIONS II

IV – 5 3 – – 8

Classification of linear partial differential equantions of second order, hyperbolic, parabolic and elliptic equations, initial value problems, the method of characteristics, boundary value problems, separation of variables, eigenfunction expansions for problems with time dependent boundary conditions or external forcing, Fourier transforms, Green's functions, cylindrical and spherical functions with applications. *W. D. Lakin*

APPLIED SCIENCE AND ENGINEERING – INTERDEPARTMENTAL

APS 100F/S COMPUTER PROGRAMMING

I – 1, 2, 3, 4, 6, 7, 8 1 – 3 7

The digital computing system as a device for numeric and non numeric transformation of numbers and symbols. Constants, variables and arrays; arithmetic and logical expressions; functions. Algorithms, represented by flow chart and computer languages. Conditional branching and looping; iteration; sub-programs; input/output. All of the above will be illustrated and implemented using the FORTRAN IV language. Applications will include root finding, numerical integration, sorting, iterative design and graph plotting.

APS 101S ENGINEERING DESIGN

I – 1, 2, 3, 4, 5, 6, 7, 8 (elective) 2 1½ 1 8

Lectures will deal with the sequence of design steps by which engineers find acceptable solutions for state technological needs. These include need definition, ideation, problem modelling, feasibility and economic analysis, the decision process, specification and presentation. A series of seminars will be used to study "case" problems and to consider such topics as the engineer's responsibility to society. Laboratory time will be devoted to small group design projects.

APS 201S ENGINEERING DESIGN

II – 5 (elective) – – 6 8

This course provides instruction and experience in the application of engineering design techniques that lead from a stated technological need to design projects and will have lecture/discussion sessions on problem identification, ideation, design criteria, feasibility analysis and decision making. Special topics related to the projects, such as materials, economics, reliability, etc., will be covered as required. At least one of the projects will be carried through to the drawing and specification stage and, if possible, constructed. Class size is limited to twenty students. Reference Books: E. V. Krick, *An Introduction to Engineering & Engineering Design*, second Edition, John Wiley and Sons; T. T. Woodson, *Introduction to Engineering Design*, McGraw-Hill. *I. W. Smith*

APS 299 PRACTICAL EXPERIENCE

Students in the programs listed below are required to have, before graduation, practical work of a nature acceptable to the department concerned. This may be obtained during the summer vacations but work done before entering the Faculty may also meet the requirements. Instructions will be issued by the departments concerning the type of work which is acceptable. Practical experience certificate forms may be obtained from the departments and should be returned there when completed.

Program 1	600 hours	Program 6	600 hours
Program 2	600 hours	Program 8	600 hours

APS 300F ENGINEERING LAW

II – 3 1 – – 2

A course designed to co-ordinate the practice of engineering and law. Consideration is given to the characteristics, advantages and disadvantages of companies, partnerships, the promotion, organization and financing of companies, the duties of employees to employers, the duties and liabilities of engineers, statutes applicable to engineering works, professional engineering associations, construction contracts, workmen's compensation, trade unions and industrial disputes. Reference Book: Laidlaw, Young, and Dick, *Engineering Law*. *E. S. Langdon, W. O. C. Miller*

APS 401 PROJECT DESIGN

IV – 1, 2, 3, 4, 5, 6, 7, 8 (elective) – – 5 8

This elective, limited to about twenty participants, provides an unusual opportunity for small interdisciplinary student design groups to seek and test solutions for engineering problems with social relevance. Considerable freedom is given in self-structuring of the groups and selection of the problems. Emphasis is placed on management of the design activity and on group effectiveness. Similar topics and instruction are selected to support the particular needs of the groups. Building and testing of prototypes, when applicable, is encouraged; written and oral presentation, with discussion of results, is required.

This course may be used for all or partial thesis requirements by arrangement with the permission of the student's department. Further details may be obtained from Professor I. W. Smith or Professor M. Townsend. *I. W. Smith*

DEPARTMENT OF CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

CHE 101S CHEMICAL ENGINEERING PROJECTS

I – 1, 2, 3, 4, 5, 6, 7, 8 (elective) – – – 8

A course concerning several topics of wide interest to engineers, in which each student may choose *three* Chemical Engineering Projects during the term. Each five week project is given by a specialist in his field of interest and includes laboratory sessions during which the student may design and execute a particular investigation related to the lecture course. Some of the projects include:

Separation Processes (Mackay)
Nuclear Kinetics (Hewitt)
Environmental Chemistry (Phillips, C. R.)
Fiber Engineering (Rozeiu)
Combustion (Sandler)
Polymer Engineering (Williams)
Photochromic Tracers (Hummel)
Ceramic Engineering (Barham)
Mineral Processing (Hewer)
Plastics Engineering (Woodhams)
Chemical Complexes (Smith, Burgess)
Catalysis (Phillips, M. J.)
Composite Behaviour (Piggott)
Biomedical Engineering (Wang)

A topic will be given in any year in which more than 20 students elect to take it.
R. T. Woodhams and Staff in Chemical Engineering

CHE 111F CHEMISTRY

I – 1, 2, 3, 4, 6, 7, 8 3 3 1 12

A basic course in physical chemistry covering the topics listed under CHE 112F but intended for students with little previous exposure to chemistry or inadequate training in chemistry. *S. Sandler and Staff in Chemical Engineering*

CHE 112F CHEMISTRY

I – 1, 2, 3, 4, 6, 7, 8 3 3 1 12

A general course in physical chemistry involving problems dealing with industrial and engineering applications. Topics discussed are stoichiometry and the mole concept, ideal and real gas behaviour, phase equilibria and colligative properties of solutions, chemical and ionic equilibrium, electrochemistry, thermochemistry and chemical kinetics.

The lecture course is supplemented by a series of laboratory experiments illustrating the principles discussed. Experiments include a gas-chromatographic study of fuel combustion, a study of caustic-chlorine, sulphuric acid and formaldehyde pilot plants, freezing point depression, molecular weight determination and binary distillations, qualitative analysis, heat of neutralization, kinetics, corrosion, pH and electrochemistry.

S. Sandler and Staff in Chemical Engineering

CHE 113F CHEMISTRY

I – 1, 2, 3, 4, 6, 7, 8 3 3 1 12

An enriched course in physical chemistry covering the topics listed under CHE 112F but intended for students who desire to learn as much about the subject matter as possible. Students entering Chemical Engineering and having Grade 13 chemistry or its equivalent are advised to take this course. *S. Sandler and Staff in Chemical Engineering*

CHE 150F CHEMISTRY

I – 5 3 3 1 10

An introduction to physical chemistry. The lectures include the following topics: ideal and real gas behavior, phase equilibria and the Clausius-Clapeyron equation, colligative properties of solutions, chemical equilibria and the Gibbs free energy, electrochemical cells and the Nernst equation, and thermochemistry. The laboratory provides experiments illustrating the principles discussed in the lectures.

W. H. Burgess and Staff in Chemical Engineering

CHE 201F PHYSICOCHEMICAL PRINCIPLES IN CHEMICAL ENGINEERING I

II – 6 2 – –

The following topics are discussed: PVT behaviour of fluids and fluid mixtures (equations of state, principle of corresponding states, compressibility factors, etc.), reaction stoichiometry, energy conversion and thermochemistry, phase equilibrium and phase diagrams. *R. W. Missen*

CHE 202S PHYSICOCHEMICAL PRINCIPLES IN CHEMICAL ENGINEERING II

II – 6 2 3 –

This course provides an introduction to chemical thermodynamics and chemical kinetics.

The second law of thermodynamics is discussed and applied to solutions, phase equilibrium, reaction equilibrium, including cell reactions and surfaces; in kinetics attention is focussed on ideal reactor models, rate laws, reaction mechanisms and catalysis. Laboratory work involves experiments for both CHE 201F and CHE 202S. *R. W. Missen*

CHE 204F ANALYTICAL CHEMISTRY

II – 6 2 $10\frac{1}{2}$ – 14

The course consists of experimental work and lectures on qualitative and quantitative chemical analysis, illustrating the principles of equilibrium and coordination chemistry and of important instrumental methods, in particular electroanalytical and opticometric methods. The growing role of analytical chemistry in environmental engineering and in the setting of environmental standards will be discussed by way of examples. Experimental work can include an independent project designed to advance the knowledge in a selected field. Textbook: Skoog and West, *Fundamentals of Analytical Chemistry*. Recommended: Fischer and Peters, *Quantitative Chemical Analysis*.

J. W. Smith, C. R. Phillips

CHE 205F INDUSTRIAL PROCESS OPERATIONS I

II – 6 3 – 2 9

The theory of momentum and heat transfer and the fundamentals of momentum, heat and mass balances of chemical engineering practice are discussed. A tutorial problem class accompanies this course. Texbooks: Faust et al, *Principles of Unit Operations*; Himmelblau, *Basic Principles and Calculations in Chemical Engineering*.

I. H. Spinner, W. G. MacElhinney

CHE 206S INDUSTRIAL PROCESS OPERATIONS II

II – 6 3 6 2 13

The fundamentals of transfer processes are discussed with particular reference to heat transfer operations in chemical engineering. A laboratory illustrating the principles and practice of transfer operations is also given. A tutorial problem class accompanies the lecture material. Texbooks: Faust et al, *Principles of Unit Operation*; McCabe & Smith, *Unit Operations of Chemical Engineering*.

W. G. MacElhinney, J. W. Smith, I. H. Spinner

CHE 207S ORGANIC CHEMISTRY I

II – 6 3 3 – 10

An introductory lecture and laboratory course in organic chemistry, with emphasis on structure. Textbook: Griffin, *Modern Organic Chemistry*. *W. H. Rapson*

CHE 208S APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

II – 6 2 – 1 6

Application of differential equations to problems of chemical engineering interest. Emphasis is on the formulation of differential equations together with their solution by analytical and numerical methods. Reference Book: Riter and Rose, *Differential Equations with Applications.* *R. L. Hummel*

CHE 209F CHEMICAL SYSTEMS

II – 5 3 3 – 8½

The themes discussed are conservation, equilibrium and rate of change in chemical systems. These are applied to topics in various engineering fields. Laboratory work illustrating the principles with emphasis on individual projects accompanies the lectures.

R. Luss

CHE 217F INORGANIC CHEMISTRY I

II – 6 2 – – 5

Useful quantum models are developed for atoms and for atomic and molecular orbital bonding mechanisms. Concepts discussed include: electronegativity, Z-effective, ionic compounds, covalent bond lengths and energies, partial ionic character of bonds, coordination and complexation. *R. L. Hummel*

CHE 218S INORGANIC CHEMISTRY II

II – 6 2 – – 5

Periodicity in physical and chemical properties of the elements are studied in relation to atomic structure. Descriptive chemistry of representative and some transition elements are correlated with structure. Textbook: Mahan, *University Chemistry* (second ed.).

R. E. Jervis

CHE 301F THERMODYNAMICS AND KINETICS I

III – 6 3 6 2 14

The power sources which have supported our civilization are ultimately based on the exploitation of chemical potentials. This course is an examination of the ultimate energy transformation and the rates at which they may be provided, together constituting a complete description of the Gibbsian power sources.

Laws of conservation and the concept of entropy together with theories of chemical reaction rates and mechanisms of selected chemical processes will be discussed in an historical context. These concepts will be illustrated by chemical engineering problems encountered in the design and operation of the means of production.

W. F. Graydon, W. H. Burgess

CHE 302S THERMODYNAMICS AND KINETICS II

III – 6 3 6 2 14

A re-statement of the material described in course CHE 301F with additional quantitative applications taken from Chemical Engineering practice. *W. F. Graydon, W. H. Burgess*

CHE 303F THERMODYNAMICS AND KINETICS I

III – 5c 2 3 – 9

Course CHE 301F with reduced laboratory and tutorial assignments. *W. F. Graydon*

CHE 304S THERMODYNAMICS AND KINETICS II

III – 5c 2 3 – 9

Course CHE 302S with reduced laboratory and tutorial assignments. *W. F. Graydon*

CHE 305F APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

III – 6 2 – 1 6

Analysis and solution of Chemical Engineering problems which require knowledge of the rational design of experiments, treatment of experimental data and tests of hypotheses. The application of probability to selected topics of Chemical Engineering interest. Reference Books: I. Miller and J. E. Freund, *Probability and Statistics for Engineers*: Bowker and Lieberman, *Engineering Statistics*. *I. H. Spinner*

CHE 309F ORGANIC CHEMISTRY II

III – 6 3 9 – 14

A continuation of course CHE 207S. Textbook: Morrison & Boyd, *Organic Chemistry*.
W. H. Rapson

CHE 310F MASS TRANSFER OPERATIONS I

III – 6 2 – 2 8

The study of the fundamentals of mass transfer. Theory and practice of applications to gas-liquid mass transfer processes, including gas absorption, stripping, drying and humidification. Textbook: R. E. Treybal, *Mass Transfer Operations, 2nd ed.*
D. Mackay, O. Trass, D. Basmadjian

CHE 311S MASS TRANSFER OPERATIONS II

III – 6 2 4½ 1 11

The study of distillation, including extractive and azeotropic distillation, solvent extraction, adsorption, membrane separation and other separation processes. Illustrative laboratory experiments. Textbook: R. E. Treybal, *Mass Transfer Operations, 2nd ed.*
D. Mackay, O. Trass, R. F. Hunter, D. Basmadjian

CHE 312F MASS TRANSFER OPERATIONS I

III – 5c; III – 2B (elective) 2 – 2 9

Course CHE 310F but with alternative assignments.
D. Mackay, O. Trass, R. F. Hunter, D. Basmadjian

CHE 313S MASS TRANSFER OPERATIONS II

III – 5c 2 – 1½ 8

Course CHE 311S with no laboratory assignments, and alternative tutorial assignments.
D. Mackay, O. Trass, R. F. Hunter

CHE 314S FLUID MECHANICS

III – 6, 2B 3 1½ 1 10

Laminar and turbulent flow of Newtonian and non-Newtonian fluids, fluid-particle systems, two-phase flow, pumps; important application of fluid mechanics in the process industries and the environment. *M. E. Charles*

CHE 315F CHEMICAL ENGINEERING PROBLEMS AND LABORATORY I

III – 5c – 2 – 7

Laboratory experiments and problems illustrating selected topics discussed in subject CHE 301F. *W. H. Burgess, W. F. Graydon*

CHE 316S CHEMICAL ENGINEERING PROBLEMS AND LABORATORY II

III – 5c – 2 – 7

Laboratory experiments and problems illustrating selected topics discussed in subjects CHE 302S and CHE 317S. *W. H. Burgess, W. F. Graydon*

CHE 317S POLYMER CHEMISTRY

III – 5c 3 – – 8

An introductory course in the chemical structures and syntheses of polymeric materials including resins, plastics, elastomers and fibers. Emphasis will be placed on the more important commerical polymeric materials and their chemical modification by crosslinking, grafting and vulcanization. Textbook: K. J. Saunders, *Organic Polymer Chemistry*, Chapman & Hall (Methuen), 1973. *R. T. Woodhams*

CHE 318S CHEMICAL ENGINEERING TOPICS

III – 6 3 – – 6

The following topics are covered:

Fundamental Process Modelling and Simulation

Modelling of elementary chemical engineering processes leading to differential equations and arising from the application of the principles of thermodynamics, kinetics, fluid mechanics, and heat and mass transfer to chemical engineering problems.
D. Basmadjian, M. E. Charles, I. H. Spinner

Organic Chemistry of High Polymers

Organic high polymers can be prepared by various mechanisms which are extensions of the organic chemical reactions studied earlier. Free radical, cationic, anionic and coordination complex catalysts produce different polymers with appropriate monomers. The nature of these reactions is discussed. *W. H. Rapson, I. H. Spinner*

Chemical Engineering Economics

A systems approach to planning chemical enterprises. The objectives, profitability and benefit-cost analyses are discussed, as are criteria for engineering decision making and typical Canadian and overseas engineering projects. Textbooks: Peters and Timmerhaus, *Plant Design and Economics for Chemical Engineers*; de Neufville and Stafford, *Systems Analysis for Engineers and Managers.* *M. Wayman*

CHE 402F CHEMICAL ENGINEERING THERMODYNAMICS

IV – 6 (elective) 2 – 1 7

Thermodynamic properties of real gases and of ideal and non-ideal liquid solutions. Chemical reaction equilibria. Selected problems. *W. H. Burgess*

CHE 404S TOPICS IN APPLIED CHEMICAL THERMODYNAMICS

IV – 6, IV – 5c (elective) 2 – 1 7

Chemical process applications of thermodynamics including compression and expansion of fluids, refrigeration and cryogenics, phase equilibrium in separation processes and reaction equilibrium in reactor processes; description of real systems in thermodynamic terms, including use of fugacity and excess functions, is developed concurrently.

R. W. Missen

CHE 405F CHEMICAL PLANT DESIGN

IV – 6 (elective) – – 6 7

This is a course based on synthesis and creativity. Teams of about 6 students each design and cost a chemical plant. The plants are chosen based on current Canadian needs and interests. *M. Wayman*

CHE 406F CHEMICAL PLANT DESIGN

IV – 5c (elective) – – 6 9

CHE 405F with alternative assignments. *M. Wayman*

CHE 407F PROCESS MODELLING AND SIMULATION

IV – 6 (elective) 2 – 3 7

Extensive practice in the setting up and solving of mathematical models of a large variety of processes connected with the chemical, metallurgical and other industries, as well as environmental and biomedical phenomena. Models involve the application of chemical engineering fundamentals (fluid flow, heat and mass transfer, chemical thermodynamics and kinetics) to the simulation of steady and unsteady state processes. Solution by analytical, analog and numerical methods. Reference book: D. Basmadjian, *Process Modelling Manual.* *D. Basmadjian, M. E. Charles, I. H. Spinner*

CHE 408F STRATEGY OF PRODUCT AND PROCESS DEVELOPMENT

IV – 6 (elective) 2 3 – 7

The strategical approaches needed for the solution of engineering problems involving the creation of novel unit operation equipment and novel processes, both for chemical and non-chemical products. *R. F. Hunter, I. H. Spinner*

CHE 409F STRATEGY OF PRODUCT AND PROCESS DEVELOPMENT

IV – 5c (elective) 2 3 – 9

CHE 408F with alternative assignments. *R. F. Hunter, I. H. Spinner*

CHE 410F ADVANCED SEPARATION PROCESSES

IV – 6 (elective) 2 – 1½ 7

Theory and application of a number of separation processes, including multicomponent distillation (using computational techniques), azeotropic and extractive distillation, liquid extraction, transient behaviour and cyclic processes, and solid-liquid contacting operations. Illustrative design problems. *D. Mackay, O. Trass*

CHE 412F PIPELINE TRANSPORTATION

IV – 6 (elective) 2 – 1½ 7

A course based on the theory and practice of moving gases, liquids and solids by pipelines both within chemical plants and over long distances. Operating pipeline systems are used as examples, and the course includes a feasibility and design study. *M. E. Charles*

CHE 413S COMPOSITE MATERIALS

IV – 6; III – 5m, IV – 8 (elective) 2 – 1 7

A course on the fundamentals of composite material design, fabrication and evaluation. Topics will emphasize recent developments in the reinforcement of plastics and metals using fibers, flakes, and other particulate fillers. Examples will include the use of such composites in automotive, marine, aircraft, building construction and allied engineering applications. Textbook: N. J. Parratt, *Fibre Reinforced Materials Technology*.

M. R. Piggott

CHE 415F POLYMER ENGINEERING

IV – 6; III – 5m, 8 (elective) 2 – 1 7

The solid state properties of polymers are discussed, particularly amorphous state and crystallinity. The rheological and viscoleastic properties are then outlined and the effect on these of degradation and failure mechanisms included. A large segment of the course applies to fabrication techniques, their principles, and the products produced. The over-all emphasis is on the relationship of the properties to the structure, and how these affect the uses. (*Not Offered in 1974–75.*) *H. L. Williams*

CHE 417F PULP AND PAPER CHEMISTRY, TECHNOLOGY AND ENGINEERING

IV – 6 (elective) 2 – 17

The chemistry of wood in relation to pulping, bleaching and papermaking processes, the equipment involved and the economics of converting wood into paper. *W. H. Rapson*

CHE 418S APPLIED NUCLEAR CHEMISTRY

IV – 6, III – 5m, 5nt, 8 (elective) 2 – 17

An introduction to the principles and methods of radioisotope chemistry. Applications of nuclear techniques and radioactive materials in chemical technology and in nuclear power generating systems. Topics to be covered include: radioisotope methods of studying chemical reaction mechanisms and kinetics, chemical process development and process control, nuclear reactions applied to chemical analysis (activation analysis), radiation chemical processing. *R. E. Jervis*

CHE 420S CERAMICS

IV – 6, III – 5m (elective) 2 – 17

An introduction to the field of ceramics, including a description of the available raw materials, the production of refractories and glasses, and high-termperature experimental techniques. *D. Barham*

CHE 423S ENVIRONMENTAL ENGINEERING

IV – 6, 2B (elective) 2 – 17

Strategy (management, law, economics) and technology for environmental control of chemical processes. Dispersion and effects of effluents in the environment. Environmental impact studies. Specifically the following are discussed: environmental standards and their bases, measurement parameters and methods, sampling and monitoring, atmospheric reactions and behaviour of wastes in water bodies, meteorological principles and dispersion, water treatment principles (primary, biological, physical and chemical) and air pollution control principles (particles and gases). *C. R. Phillips*

HE 425S INSTRUMENTAL METHODS

IV – 6 (elective) 2 – 17

The subject is designed to emphasize the science of chemical instrumentation. The principles, techniques, and applications of gas-chromatographic, opticometric, electrometric and mass-spectometric methods of analysis are studied. *S. Sandler*

CHE 426S ADVANCED INORGANIC CHEMISTRY

IV – 6 (elective) 2 – 17

Periodicity and trends in physical and chemical properties of the compounds of the principal elements are discussed. These are correlated, predicted and classified both in terms of classical concepts and equations of quantum mechanics. *R. L. Hummel*

CHE 427F INTRODUCTION TO NUCLEAR ENGINEERING

IV – 6, 8 (elective) 2 – 1

Nuclear engineering aspects of: nuclear constitutions and properties including cross-sections, energetics, radioactivity; production and use of radio-isotopes; neutrons slowing-down, diffusion of thermal neutrons; fission, the fission reactor; heat transfer radiation measurement and control; materials for reactor fuel, can, moderator and coolant and their behaviour in the nuclear environment. *D. G. Andrews*

CHE 429S NUCLEAR REACTORS AND INSTRUMENTS

IV – 7, 5e (elective) 2 1½ 1

The purpose of this course is to provide electrical engineering students with an orientatio in the nuclear energy field and to develop in terms of the basic physical processes involve an understanding of (1) the kinetic behaviour of nuclear reactor systems and (2) th principles of operation of nuclear instruments for application in industry, medicine an nuclear research. The six laboratory periods associated with this course provide intensiv involvement with actual nuclear facilities including the SLOWPOKE critical reactor, th uranium-heavy water neutron multiplying assembly, and modern radiation spectrometers. In addition, special laboratories stress the fundamental aspects of nuclear radiatio measurement and reactor analog simulation. *J. S. Hewit*

CHE 431S OPTIMAL CONTROL

IV – 6 (elective) 2 – 1

Fundamentals of optimal control of engineering systems are developed from the state space viewpoint. The use of dynamic programming, maximum principle, and othe optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic method phase-space representation and the application of some elementary principles of asymptotology. Textbook: Lapidus and Luus, *Optimal Control of Engineering Processes.*

R. Luu

CHE 432F CHEMICAL REACTORS

IV – 6 (elective) 2 – 1

An introduction to the rational design and analysis of chemical reactors. Topics are chemical kinetics and development of the rate law, including homogeneous an heterogeneous systems and catalysis; reactor models (batch, tubular, stirred-tank), including isothermal, non-isothermal and adiabatic operation. Reference Books: K. G Denbigh, *Chemical Reactor Theory*; O. Levenspiel, *Chemical Reaction Engineering.*

R. W. Misse

CHE 434S SELECTED TOPICS IN ORGANIC CHEMISTRY

IV – 6, 5c (elective) 2 –

A course on the creative aspects of applied organic chemistry. The topics to be discusse are selected from the Nobel Lectures delivered annually since 1902, and from outstanding Canadian contributions to synthetic organic chemistry. Special attention will be given to the mechanisms and the influence of molecular structures on the course of reactions. Various experimental techniques and their operating principles used in applied organic chemistry will be explained. Methods for the sequential degradation and the reconstruction of complex organic molecules will be illustrated with particular references to carbohydrates, proteins, heterocyclic compounds, steroid hormones, and alkaloids.

P. Y. Wang

CHE 435F RATE PROCESSES I

IV – 5c 3 – – 9

Introduction to momentum, heat and mass transfer. Transport properties from kinetic theory of gases. Fluid flow concepts, integral mass, force and energy balances, Bernoulli's equation, friction. Equations of motion and boundary layer equations. Turbulent transport. Compressible flow. *O. Trass*

CHE 436S RATE PROCESSES II

IV – 5c 3 – – 9

Total energy and thermal energy equations. Heat Transfer: Fourier's laws, heat transfer coefficients and equations. Component mass balances, mass transfer coefficients and Fick's laws. Momentum, heat and mass transfer analogies. Applications of the above fundamentals. *O. Trass*

CHE 437F OPTIMAL CONTROL OF CHEMICAL SYSTEMS

IV – 5c (elective) 3 – 1½ 9

Fundamentals to optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: Lapidus and Luus, *Optimal Control of Engineering Processes.*

R. Luus

CHE 440S MODELLING AND SIMULATION OF CHEMICAL SYSTEMS

IV – 5c (elective) 3 – – 9

Applications of elements of chemical and physical rate processes to Chemical Engineering problems. Chemical reactor stability, complex chemical system dynamics and process control. Application of analog, digital simulation, and hybrid computers to the solutions of problems in the above topics. *I. H. Spinner*

CHE 441F CHEMICAL ENGINEERING PROJECT

IV – 5c (elective) – 6 – 9

An experimentally oriented research project. *Senior Staff in Chemical Engineering*

CHE 442F NUCLEAR REACTOR FUNDAMENTALS

IV – 5nt 3 3 – 1 1

This course, using appropriate mathematic tools, explains in terms of fundamental physical processes the design considerations and operational behaviour of existing, projected, and conceptual nuclear reactor systems for the generation of useful energy or radiation products. The physical processes of importance are nuclear fission, nuclear fusion, neutron diffusion, the interaction of various types of radiation with nuclear and condensed matter, and the heating and containment of plasmas. Topics include the conditions for criticality, the kinetic behaviour and the control of fission chain reactors, as well as the projected criteria whereby controlled fusion will become a reality. Environmental aspects and the international implications of nuclear energy will be discussed. The laboratory periods provide a first-hand opportunity to study the kinetic response of the SLOWPOKE critical reactor and to perform reactor physics measurements on the uranium heavy-water neutron multiplying assembly. The use of radiation sources and modern nuclear instruments in a variety of applications is investigated. Electrical analogs are used to supplement kinetic studies of reactor systems. (Prerequisite: PHY 335F or equivalent) Textbook: Lamarsh, *Nuclear Reactor Theory*, Addison-Wesley.

D. G. Andrews, J. S. Hewitt

CHE 443 ORGANIC CHEMISTRY

(elective) 2 3 – 8, 2 3 – 8

A comprehensive, elementary, organic chemistry course available to students in any year other then those enrolled in Program 6, intending to qualify for entrance into the Faculty of Medicine. Lectures and laboratories are scheduled at times convenient to those registered. The lectures cover the simple hydrocarbons, their halogen and oxygenated derivatives, amino derivatives, and other derivatives of importance to biological systems, all with emphasis on structure and functionality. The major part of the course is spent on amino acids, sugars, and fatty esters with emphasis on natural and synthetic polymers of biological interest or use. The concurrent laboratory emphasizes typical laboratory reactions of these classes of materials. (*Not Offered 1974–75.*) *H. L. Williams*

CHE 444S PLASTICS ENGINEERING

IV – 6 (elective) 2 – 1

An intensive study of the chemical and physical properties of plastics materials and thei use in product design. The principles of reinforcement with respect to fillers, fibers, flake and microballoons will be presented including the practical aspects of materials selection processing, fabrication and evaluation. The tutorial periods will be devoted to actual cas histories involving recent developments. Reference Book: The Modern Plastics Encyclopedia. Textbook: G. Lubin (ed.), *Handbook of Fiberglass and Advanced Plastics Composites*, Van Nostrand Reinhold 1969. *R. T. Woodhams*

CHE 445S PETROLEUM ENGINEERING

IV – 6 (elective) 2 – 1 7

A course utilizing the principles of Chemical Engineering and presenting the fundamentals of engineering design and processing as they apply to refinery operations that produce petroleum products and important chemicals from petroleum. *W. G. MacElhinney*

CHE 446F ATMOSPHERIC DISPERSION

IV – 6 (elective) 2 – 1½ 7

Problems of assessing the dispersive role of the atmosphere as a means of controlling air pollution are considered, as well as related topics such as source sampling and effects of air quality on the feasibility of industrial plants and residential areas. Textbook: *Meteorology and Atomic Energy*, 1968. *J. W. Smith*

CHE 447S CATALYSIS

IV – 6 (elective) 2 – 1 7

An introduction to heterogeneous and homogeneous catalysis including adsorption, kinetics of catalytic reactions, the nature of the catalyst surface and a consideration of some specific catalytic reactions. *M. J. Phillips*

CHE 448F INDUSTRIAL BIOLOGICAL PROCESSES

IV – 6 (elective) 2 – 1 7

Principles involved in the industrial handling of biological materials for food purposes. Engineering operations in the manufacture of food products. Invited lecturers will cover specialized industrial topics. *H. D. Bett*

CHE 449S NUCLEAR CHEMICAL ENGINEERING

IV – 6 (elective) 2 – 1 7

Fuel cycles; large-scale production of transuranium elements; growth and decay of fission product activities; chemical processing of irradiated fuels – extraction, absorption, complexing, chemical separation; transport and storage of radioactive wastes; environmental problems; isotope separation by physical means – diffusion, centrifuges, cascades.
D. G. Andrews, R. E. Jervis

CHE 452S NEUTRON AND PHOTON TRANSPORT

IV – 5nt 3 – 2 10

This is a course on radiative transport theory and its specific application to problems in nuclear energy such as reactor and accelerator shielding, the optimal design of reactor attice configurations, the prediction of reactor fuel burnup, and the implications of these for reactor control and fuel cycle management.

The Boltzmann transport equation is derived in general form and its historical significance indicated. Analytical and numerical solutions are investigated and realistic scattering kernels for neutrons and photons are developed. The current state of computer code development for reactor calculations is reviewed. (Prerequisite: PHY 335F and APM 441F or equivalents). Textbook: Case and Zweifel, *Linear Transport Theory*, Addison-Wesley, 1967. *D. G. Andrews, J. S. Hewitt*

CHE 453S ELECTROCHEMICAL ENERGY

IV – 6 (elective) 2 – 17

Emphasis is on the New Electrochemistry and its major role in the electricity-based society of the near future. Topics discussed include the fundamental equations of electrodics at the charged interface, fuel cells, conventional battery the new high-energy batteries, electrochemical power sources for vehicle propulsion, and the concept of a hydrogen economy. *F. R. Foulkes*

CHE 454F ENERGY, ENVIRONMENT, AND RESOURCES

IV – 6 (elective) 2 – 17

Society is moving steadily towards decreased dependence on non-renewable energy and material resources while seeking to ensure maintenance of a satisfactory environment. The role of applied chemical science in these changes is described with emphasis on Canadian conditions. Topics discussed in detail include: current and future energy souces, conversion usage and conservation; process effluent treatment and elimination; resource recycling; environmental impact assessment and ecosystem analysis; resources depletion; policies to ensure beneficial technical change; Canadian Arctic development. The course will consist of lectures and individual student projects and presentations on relevant topics. *D. Mackay*

CHE 455F TOPICS IN HEAT TRANSFER

IV – 6 (elective) 2 – 17

Heat transfer is an important design and operating aspect of chemical reactors and various important separation processes of the chemical industry. The course covers the principle modes of heat transfer—conduction, convection and radiation—in conditions of steady and transient states, change of phase, and industrial conditions. The course goes beyond the standard textbook and into areas of controversy. *R. L. Hummel*

CHE 456F ECONOMIC EVALUATION IN THE PROCESS INDUSTRIES

IV – 6 (elective) 2 – 1

The course presents a clear conception of how to prepare and evaluate investment proposals. Practical applications will be discussed in addition to techniques and theories of investment evaluation. Emphasis will be placed on such topics as the reading and interpretation of financial statements; a firm's cost of capital; the economics and relative feasibility of new projects, plant modernization and expansion, "make or buy", "buy or lease", "replace or repair", "abandonment", and uncertainty and inflation in economic evaluations. *A. J. Szony*

CHE 457S MOMENTUM, HEAT AND MASS TRANSFER

IV – 6 (elective) 2 – 1 7

Unified treatment of momentum, heat and mass transfer processes. Balance equations, boundary layer theory, transfer analogies for turbulent flow. Flow systems with simultaneous heat and mass transfer and chemical reaction. Applications. *O. Trass*

CHE 499 THESIS, PUBLIC DISSERTATION AND SEMINAR

IV – 6 – 8 2 10, – 12 3 17

The thesis will be graded after submission in the spring term and the grade included in the weighted average for that term only. The weight assignment will be the sum of the weights for both terms. *Senior Staff in Chemical Engineering*

DEPARTMENT OF CIVIL ENGINEERING

CIV 100F APPLIED MECHANICS

I – 1, 2, 3, 4, 6, 7, 8 3 – 2 10

Statics: The principles of statics are applied to the composition and resolution of forces, moments and couples. The equilibrium states of frames are examined. Dynamics: Applications of the principles of dynamics are discussed for motion on straight and curved paths. Work, energy and momentum concepts are applied to particles, systems of particles and rigid bodies. Throughout statics and dynamics the free body concept is emphasized and vector algebra is used where it is most useful.

G. T. Will and Staff in Civil & Mechanical Engineering

CIV 101F MECHANICS (STATICS)

I – 5 2 – 1 6

Translational and rotational resultants and equilibrants are discussed together with equivalent force systems in two- and three-dimensional space. Emphasis is placed on systems in equilibrium. Distributed forces, applications to structures, friction, method of virtual work, potential energy and stability of equilibrium are considered.

S. M. Uzumeri, K. A. Selby

CIV 135F/S ENGINEERING GRAPHICS

I – 1, 2, 3, 4, 6, 7, 8 2 5 – 8

A course to provide an introduction to graphical communication in contemporary engineering practice. Topics in descriptive geometry and engineering drawing include orthographic projection, single view drawings, spatial analysis, developments and intersections, sketching, preparation of graphs and nomographs and the reproduction of drawings.

CIV 136S ENGINEERING GRAPHICS

I – 5 (elective) 2 – 2½ 8

A course on the use of graphical theories and methods as a means of visual communication in the development of engineering concepts. The lectures and laboratory problems deal with the ideas, problem refinement, solution analysis and solution implementation.

R. D. Foster

CIV 203S MECHANICS OF MATERIALS

II – 5 (elective) 2 – 3 8

Structural design philosophy and methods; structural properties of engineering materials: basic relationships between force and deformation of bars; behaviour of structural components subject to axial load, bending, shear, and torsion; stress and strain transformations; instability; design of simple structures. *M. P. Collins*

CIV 204F MECHANICS OF MATERIALS

II – 8; II – 4, III – 4 (elective) 3 1½ – 8

The fundamental relations among stress, strain and applied load are worked out for tension, compression, twisting and bending in the elastic and inelastic ranges, for various engineering materials. The buckling of struts and columns is examined. Laboratory: An experimental study of engineering materials and structural members under various loading conditions. (Prerequisite: CIV 100F) *A. C. Davidson*

CIV 205S MECHANICS OF MATERIALS

II – 4 (elective) 2 3 –

An introduction to the elastic behaviour of solids under various load conditions. The basic concepts of strength and stiffness are examined and their application to the design o elementary structural systems considered. Laboratory: An experimental study of en gineering materials and structural members under load. (Prerequisite: CIV 100F)

J. D. Barbe

CIV 209S ENGINEERING MATERIALS

II – 1 4 2 1 1

Deals with the basic principles necessary for the undertaking and selection of material used in Civil Engineering and points out the significance of these in practice. Fundamen tals which provide a common basis for the properties of various materials are stressed One third of the laboratory time is devoted to demonstrations illustrating the fundamen tals covered in the lectures, the remaining time to project work in small groups (Prerequis ite: CIV 210F) *J. Timusk, G. B. Craig*

CIV 210F STRENGTH OF MATERIALS

II – 1, 2 3 – 1

An introduction to the elastic and inelastic behaviour of solids under various loa conditions. Stress, strain, and deformation relations are determined for members subjected to tension, compression, torsion and bending forces. (Prerequisite: CIV 100F)

P. C. Birkemoe, P. M. Wright

CIV 211S MECHANICS AND DESIGN OF STRUCTURES

II – I 4 – 2 10

This course is primarily an introduction to structural design and topics examined include basic concepts, types of structures, loads, safety factors, specifications and common failure modes. The design of structural components in steel, concrete and timber using the National Building Code is investigated.

Topics to be covered in engineering mechanics include virtual work, energy methods in structural analysis and an introduction to vibration. (Prerequisite: CIV 210F)

S. M. Uzumeri

CIV 240S ENVIRONMENTAL SYSTEMS

II – I 2 – – 5

An examination of the causes of environmental deterioration (through population growth, economic growth, urbanization and industrialization, resource exploitation and recreation) and their effects on natural and man-made systems. Technology of water, air, soil and noise pollution control. Examination of alternative strategies for environmental management. *G. W. Heinke*

CIV 255F SURVEYING

II – I 3 2 1 9

General principles and practice of surveying including: measurement of horizontal distances, horizontal angles, vertical distances. Survey calculations, sources of errors, corrections and adjustments. Route surveying, construction surveying and introduction to airphoto interpretation and photogrammetry.

B. J. Haynes and Staff in Civil Engineering.

CIV 260F COMPUTER PROGRAMMING

II – I 2 – 2 8

This course continues the study of programming requirements and techniques introduced in course APS 100F/S; the full standard FORTRAN language is used; emphasis is placed on subprogram philosophy and organization, and on flow charts and program documentation. Engineering problem oriented languages such as ICES-COGO and ICES-STRUDL are introduced and used. Some experience is provided in the use of a time-shared interactive computing system and in computer graphics. (Prerequisite: APS 100F/S)

R. A. Collins

CIV 267F THE ENGINEER AND HIS ENVIRONMENT

II – I 2 2 2 8

An introduction to the role of the engineer in the solution of society's problems. Lectures, seminars and discussion periods by staff of all areas of Civil Engineering and guest speakers. Projects on qualitative solutions to engineering problems. Instruction and practice in presentation of technical data and reports. *Staff in Civil Engineering*

CIV 271S PROBABILITY AND STATISTICS

II – I, 2 3 – 2 8

An introductory course which combines the theory of probability, including Binomial, Poisson, and normal distributions, frequency and sampling distributions, parameter estimation, hypothesis testing, experimental design and linear regression, with practical examples and exercises related to Civil Engineering. *G. N. Steuart*

CIV 280F ELEMENTS OF STRUCTURAL ENGINEERING

Architecture (elective) 2 – 2 8

Intended primarily for students in Architecture, this course examines the fundamentals used in the analysis and design of building components. Topics to be covered include equilibrium principles, introduction to the structural properties of common building materials and to basic strength of materials. Finally these fundamentals are used in the design of some simple structures. *R. H. Mills*

CIV 312F DESIGN OF STRUCTURES II

III – I 3 – 2 9

A course on the design of structures with emphasis on the design and analysis of determinate systems. Detailing and fabrication aspects of such structures in steel and in reinforced concrete are examined. (Prerequisite: CIV 211S) *J. D. Barber*

CIV 313S DESIGN OF STRUCTURES III

III – I 3 – 2 10

A course on the design of structures with emphasis on indeterminate systems. Topics considered include the analysis of indeterminate structures by moment distribution and by approximate methods, design of reinforced concrete footings, retaining walls and continuous slabs, introduction to prestressed concrete. (Prerequisite: CIV 312F)

P. C. Birkemoe, J. Schwaighofer

CIV 314S STRUCTURAL DESIGN

III – 2C 2 – 3

This course is an introduction to the design of steel, timber and reinforced concrete structures. Topics to be covered include types of loads, specifications, design of beams and columns, design of reinforced concrete slabs and an examination of the structura systems for light industrial buildings.

CIV 321F SOIL MECHANICS

III – I, 2C; III – 2A, 2B, IV – 2A (elective) 2 1 –

Identification and classification of soils for engineering purposes; properties, permeabil ity and drainage characteristics, effective stresses, consolidation and settlement, shearing strength, compaction, stabilization, frost action. Laboratory sessions include identification of soil samples and determination of mechanical properties of soil. (Prerequisite: CIV 210F) *E. I. Robinsky*

CIV 322S FOUNDATIONS

III – I, 2C; 2A (elective) 2–27

Site investigations and sampling, response of soil to load, lateral earth pressure, retaining walls, braced cuts, anchored bulkheads, bearing capacity, shallow foundations, settlement, deep foundations, slope stability. Laboratory sessions are devoted to design problems. (Prerequisite: CIV 210F, CIV 321F) *F. A. DeLory*

CIV 327S PLEISTOCENE GEOLOGY

III – 2C; 2A (elective) 3–28

The causes, extent, and effects of Pleistocene ice caps, especially in North America. Origin and classification of land-forms of glacial origin. Methods of dating and analyzing these deposits. Periglacial phenomena, including permafrost. The extent of and the economic and engineering significance of glacial deposits in North America. (Prerequisite: GLG 120F/180F/280S) *J. D. Morton*

CIV 330F TRANSPORTATION SYSTEMS

III – 1 3–28

A brief history of Canadian transportation development and a discussion of current policy, regulation and administration structure introduces a comparative study of transportation modes including their cost characteristics. The principles of location, flows on networks and the concepts of capacity and control are studied. The transportation planning process is introduced with emphasis on analytical techniques.

R. M. Soberman

CIV 338S URBAN AND REGIONAL PLANNING TECHNIQUES

III – 1, 2C, IV – 1 (elective) 3–28

This course provides an introduction to the basic techniques used by urban and regional planners in the planning process. Topic areas will include methods of analysis, forecasting, simulation techniques and the regulation of land use. Practical applications will be emphasized in a series of brief laboratory assignments. *R. W. McCabe*

CIV 340S MUNICIPAL ENGINEERING

III – 1 2–27

Systems for the supply, distribution and storage of water and for the collection of wastewater and stormwater are studied in detail. Other municipal problems dealt with include; pumping stations, roads, land development, refuse disposal and the financing and administration of public works. Individual and group design projects supplement the lectures. (Prerequisite: MEC 351F, corequisite: CIV 240S) *J. G. Henry*

CIV 358F SURVEY CAMP

III – 1 ---8

At Survey Camp, students obtain further experience in the use of instruments and in the essentials of survey practice. Emphasis is placed on adjustments of levels and transits, route surveys, higher order surveys, topographic surveys, practical astronomy and photo interpretation. Students entering Third Year Civil Engineering will be required to take the Survey Camp from August 19 to September 3, 1974.

The camp is held at Dorset and Gull Lake with students in attendance paying for the cost of their accommodation.

Applications to defer attendance or for exemption from the camp must be made to the secretary of the Faculty before July 15, 1974. (Prerequisite: CIV 255F)

B. J. Haynes and Staff in Civil Engineering

CIV 368S CIVIL ENGINEERING SYSTEMS

III – 1 2228

The analysis and design of comprehensive engineering systems by student groups, with examples from structural, geotechnical, transportation, and environmental engineering. Emphasis is placed on the evaluation of alternative technological designs and the integration of knowledge from many courses in the curriculum. Lectures are given on systems engineering, data analysis procedures and sensitivity testing.

CIV 370F ENGINEERING MATHEMATICS

III – 1, 2C 3–28

Numerical integration, solution of ordinary and simple partial differential equations by numerical procedures, solution of linear algebraic equations, mathematical programming. (Prerequisite: MAT 280F) *G. T. Will*

CIV 375S ENGINEERING ECONOMICS AND DECISION MAKING

III – 1, IV – 1 (elective) 3–28

Design as selection between alternatives. Economic efficiency and other goals. The objective function and the use of optimization techniques. Time scale of consequences and its reduction. Interest rate and social rate of return. Market and non-Market valuation. Economic life, replacement and salvage value. Treatment of risk and uncertainty. Public investment. Financing. *E. Hauer, G. N. Steuart*

CIV 405F ADVANCED STRENGTH OF MATERIALS

IV – 1 (elective) 3–28

Selected topics from the following list are introduced or extended beyond their elementary treatment: elastic buckling of axially loaded bar; torsion of bars having non-circular cross sections; unsymmetrical bending of beams; beams on elastic foundations; curved beams; beam-columns; cables; rings; elementary theory of elasticity; elementary plate theory. *J. Schwaighofer*

CIV 413F MODULAR CONSTRUCTION

IV – 1 (elective) 3 – 2 8

Systems building approach, types of modular construction. Fundamentals of building science. Materials for modular construction analysis and design of various modular systems, including panelized construction, formless masonry construction, and prefabricated box units. Joining and erection techniques. Recent developments. *V. R. Riley*

CIV 414S ADVANCED ENGINEERING MATERIALS

III – 1, 8, IV – 1 (elective) 3 – 2 8

In recent years, materials have been subjected to increasingly higher stress levels and corrosive environments. In order to meet these demands, designers have turned to newer materials and structures such as insulating concretes, sandwich panels, polymer modified concretes, and fibre reinforced composites. This course introduces some of the newer materials and techniques which are available, and also deals with conventional problems such as brittle fracture of steel structures. *R. H. Mills*

CIV 416F REINFORCED CONCRETE I

IV – 1 (elective) 3 – 2 8

This course covers the behaviour and ultimate strength of reinforced concrete structures. Members subjected to flexure, axial load, shear and torsion are treated. Detailing of reinforcement, the design of floor systems and the design of shear walls are covered. Emphasis is given to the relationship between recent research results and current building codes. (Prerequisite: CIV 313S) *M. P. Collins*

CIV 417S REINFORCED CONCRETE II

IV – 1 (elective) 3 – 2 8

Prestressed Concrete – tension members, simple span and continuous span flextural members, columns and torsion resisting members. Slender reinforced columns. Yield line methods for slab analysis and design. (Prerequisite: CIV 416F) *M. W. Huggins*

CIV 418S BEHAVIOUR AND DESIGN OF STEEL STRUCTURES

IV – 1 (elective) 3 – 2 8

The behaviour of structural elements and structures and their connection by welding and bolting are examined and related to design methods and criteria. Topics to be considered include repeated loading, brittle fracture, elastic-inelastic behaviour, buckling and ultimate capacity. (Prerequisite: CIV 313S) *P. C. Birkemoe*

CIV 419F INDETERMINATE STRUCTURES

IV – 1 (elective) 3 – 2 8

Internal forces, support reactions, structural displacements and influence lines are computed for continuous beams, arches, closed rings, frames, trusses, Vierendeel trusses and grids. Slope-deflection, moment distribution, Kani, flexibility and stiffness methods, virtual work and Muller-Breslau principles, and Maxwell's law of reciprocal displacements are studied. An introduction to structural analysis by matrix organization is examined. (Prerequisite: CIV 313S) *R. A. Collins*

CIV 420S CONSTRUCTION ENGINEERING

IV – 1, 2C (elective) 3–28

This course deals with business and management aspects of construction – construction company organization, construction tenders and contracts, the elements of construction project, project management, planning and scheduling, job administration, field engineering; and construction methods and equipment. A number of construction sites and construction material manufacturing plants are visited during the scheduled laboratory periods. *K. A. Selby and Staff in Civil Engineering*

CIV 421F FOUNDATIONS AND EARTHWORK

IV – 1, 2C (elective) 3–28

Design and construction of: foundations for buildings, bridges and other structures including excavation, footings, piling, caissons; retaining walls, sheet pile bulkheads; fills, embankments, earth-fill and rock-fill dams including seepage, dewatering and grouting. The laboratory sessions include design problems and studies of case histories. (Prerequisite: CIV 322S) *E. I. Robinsky*

CIV 422S ENGINEERING GEOLOGY

III – 1, IV – 1 (elective) 3–28

The study of engineering practice from a geological point of view. The behaviour of rocks and soils in building and engineering construction, foundations, tunnels, dams, and flood-control works with reference to the importance of the mineral composition of earth and rock materials, their geomorphic and geologic features and their stress history. Engineering case studies will include examination of groundwater, frost and landslide conditions, shoreline engineering, construction in permafrost, earthquake problems, and field investigations. (Prerequisite: GLG 280S/GLG 180S) *E. I. Robinsky*

CIV 423S ENGINEERING GEOLOGY SEMINARS

IV – 2C 3–28

Applications of geology to evaluation of natural problems (erosion, situation, landslides), regional problems (groundwater, permafrost) and construction problems (dams, tunnels, canals, construction materials). Course is based on study of case histories. Term paper is required. *M. Kalin*

CIV 424F ROCK MECHANICS

IV – 2C 3–28

Physical properties of rock, fundamentals of rock behaviour, and theories of rock failure. Consideration of in situ stresses. Analysis of stress and strain. Elementary principles of design of open excavations and underground excavations. Consideration of testing, excavation support, and instrumentation. *T. C. Kenney*

CIV 425F SUBSURFACE EXPLORATION

IV – 2C 3 – 2 8

Planning and executing subsurface explorations in soils and rock to obtain information for the design, construction control and operation of civil engineering and mining projects, and for carrying out remedial actions in the case of distressed structures or distressed areas. Indirect methods (mapping, shallow seismic, pumping, penetration), direct methods (boring, shafts, adits), in situ tests and field instrumentation will be considered. Case histories will be studied. *J. D. Morton*

CIV 428S DESIGN OF EARTH AND ROCK STRUCTURES

IV – 2C 2 – 3 8

Design of: cuttings in soil and rock, embankments and dams of earth and rock fill and openings in earth and rock such as tunnels and cavities. Consideration will be given to: appreciation of site conditions, site selection, material selection and/or exploration, design and analysis, construction control, monitoring of performance, seepage control, remedial measures. Tutorial sessions will consist of design projects.

CIV 429F AIR PHOTO INTERPRETATION

III – 2A, IV – 1 (elective) 3 2 – 8

The principles of interpretation of aerial photographs; processes of formation and erosion of landforms, both unconsolidated and consolidated, with particular emphasis on glaciation, their patterns as seen on aerial photographs, their identification and evaluation, and the engineering problems involved; location of granular materials; soil mapping; investigations from airphotos for highway, powerline, and pipeline locations, damsites and flood control structures; delineation of drainage areas and drainage structure location; classification of muskeg areas and prediction of depth, land use classification. One day field trip, including field soil testing. *J. Vlcek*

CIV 430F TRAFFIC ENGINEERING

IV – 1 (elective) 3 – 2 8

Introduction to the basic principles and methods of Traffic Engineering. Driver, vehicle and roadway characteristics. Description and measurement of traffic streams. Micro and microscopic properties. Highway intersection capacity. Traffic accidents, their relation to design and their control. Traffic signing and signalization. Area traffic control and surveillance. Illumination. Parking. (Prerequisite: CIV 330F) *E. Hauer*

CIV 431F TRANSPORTATION PLANNING

IV – 1 (elective) 3 – 2 8

This course deals with the transportation planning process, with emphasis on urban and regional applications. Surveys and data collection, mathematical models and transportation demand analysis, transit and highway system alternatives, methods of project and systems evaluation. *R. G. Rice*

CIV 432S HIGHWAY ENGINEERING

IV – 1 (elective) 3–28

A basic course in which the following topics are examined: highway systems and geometric design; highway materials and their behaviour; and, pavement systems. The laboratory part of the course is mainly devoted to a design project. *M. M. Davis*

CIV 439S URBAN AND REGIONAL PLANNING

IV – 1 (elective) 3–29

Spatial distribution of land use related to physical, ecological and transportation factors. Economic alternatives for the selection of industrial, residential and recreational location. Land use planning concerning natural resources, resource potential and conservation. Legal aspects of planning. Mathematical modelling and optimization of land use. (Offered jointly by the Department of Urban and Regional Planning and Civil Engineering.) *A. Waterhouse*

CIV 440F WATER AND POLLUTION CONTROL ENGINEERING

IV – 1, 2A, 2C (elective) 3–28

The basic problems of water and soil pollution and the engineering solutions currently available. The self purification of streams and the physical, chemical and biological treatment processes employed in the design of water and wastewater treatment facilities. Laboratory demonstrations and field trips complement the lectures and class assignments. *J. G. Henry*

CIV 441S AIR POLLUTION CONTROL ENGINEERING

IV – 1 (elective) 3–28

The pollutants: their sources, quantities and qualities, effects on humans, environment. Distribution and concentrations in city air under various atmospheric conditions, pollution indices. Control processes: change of fuel, dust control by cyclones and electrostatic precipitators; control of gases by adsorbers and scrubbers; exhaust controls for vehicles. Impacts on economy, planning, policy decisions. *A. P. Bernhart*

CIV 449S GROUNDWATER

IV – 2C 2–38

Ground water as an element of the hydrologic cycle; its relation to the geology of a basin and to water resources management. Mechanics of groundwater flow; methods of investigation and exploitation. *M. Kalin*

CIV 450F WATER RESOURCES AND HYDROLOGY

IV – 1, 2C (elective) 3–28

The availability and management of water for optimal use in the broadest sense. Qualitative and quantitative evaluation of surface and ground water sources. Rainfall, run-off and stream-flow analysis. Storage, flood control, diversion and related hydraulic structures. Uses of water and forecasting the demand. Quality standards, ecological, economic, sociological, legal and political factors affecting water management. Benefit, cost analysis. *P. E. Wisner*

CIV 455F PHOTOGRAMMETRY AND REMOTE SENSING

IV – 1, 2A, 2C (elective) 3 2 – 8

Camera as a measuring instrument. Photogrammetric properties of pictures, construction viewing and measuring of stereoscopic models. Applications in engineering, and mapping. Physical aspects of remote sensing. Spectral characteristics of natural objects. Photographic and nonphotographic remote sensors and their applications in terrain studies, vegetation analysis and natural resource management. Analysis of Earth Resource Satellite data. *J. Vlcek*

CIV 456S ENGINEERING APPLICATIONS OF SURVEYING

III – 1, IV – 1 (elective) 3 – 2 8

Theory methods and instrumentation of engineering surveys. Special applications in civil engineering structures such as: bridges, dams, tunnels, highways, airports, power lines, and pipelines. Introduction to hydrographic surveying. Engineering applications of and introduction to legal surveying as related to engineering projects. (Prerequisite: CIV 358F) *B. J. Haynes*

CIV 474S PUBLIC SPEAKING

IV – 1 – – 2 3

A subject emphasizing student participation and designed to develop facility in oral presentation before groups. Beginning with short talks, students move on to longer prepared talks on technical subjects. Experience and observation are also offered in the conduct of meetings. *H. L. Macklin & Staff in Civil Engineering*

CIV 475F ADMINISTRATION AND MANAGEMENT

IV – 1, 2C 2 – – 6

An introduction to the various management functions involved in operating a business; including planning, organizing, staffing, directing, controlling and labour relations. Individual proprietorships, partnerships, and limited company operations are discussed.

K. A. Selby, H. L Macklin

CIV 479F/S SPECIAL STUDIES IN CIVIL ENGINEERING

IV – 1 (elective) 3 – 2 8

Students having the Departmental Chairman's approval, may undertake special studies of advanced topics that are not normally part of the undergraduate program. *G. W. Heinke*

CIV 498F THESIS

IV – 1(elective) – 4 – 8

With the approval of the Departmental Chairman, a Fourth Year student in Civil Engineering may undertake a 20-unit thesis instead of the usual 12-unit thesis (CIV 499S).

Normally such theses will be experimental in nature and the topic must be submitted prior to the commencement of the fall term. *G. W. Heinke*

CIV 499F/S THESIS

IV – 1 –6 – 12

All students in the Fourth Year of the Civil Engineering program must prepare a thesis on an approved subject. Topics are normally submitted for approval in the fall term with the work being done in the spring term under the supervision of a faculty member. (Only those students who will complete the requirements for their degree in a fall term will be permitted to take CIV 499F.) *G. W. Heinke*

COMMERCE

(Department of Political Economy)

COM 390F ACCOUNTING I

III – 4 2 – – 8

Accounting methods and principles; build-up of financial statements. *M. S. Shapiro*

COM 391S ACCOUNTING II

III – 4 (elective) 2 – 1 8

Analysis and interpretation of financial statements; introduction to cost accounting and managerial accounting. (Prerequisite: COM 390F) *M. S. Shapiro*

DEPARTMENT OF COMPUTER SCIENCE

CSC 180F INTRODUCTION TO COMPUTER PROGRAMMING

I – 5 2 2 – 6

A practical introduction to algorithms and PL/1 programming; numerical and non-numerical applications. *R. Baecker*

CSC 236S NUMERICAL METHODS

III – 8 2 – 17

Solution of non-linear equations, approximations, quadrature, solution of systems of linear equations, eigenvalues and eigenvectors, differential equations. Exercises requiring the use of a computer will be assigned. (Prerequisites: APS 100F/S, Mat 187S, MAT 189S. Exclusions: CSC 381F, 386F, 281F, 481S) *N. A. Derzko*

CSC 280S COMPUTER LANGUAGES

II – 5 (elective) 2 – 1 8

Definition of various programming languages including procedure oriented list processing and simulation languages. Specification of syntax and semantics. Basic properties of programming languages. Introduction to formal languages and data structures. (Prerequisite: CSC 180F) *J. N. Hume*

CSC 281F NUMERICAL METHODS

II – 5 2 – 17

Non-linear equations, matrices and systems of linear equations, interpolation and approximation, quadrature, solution of ordinary differential equations. Reference: Conte, de Boor, *Elementary Numerical Analysis*, McGraw-Hill, 1972. (Prerequisites: CSC 180F, MAT 185F, 194F, 195S. Exclusions: CSC 236S, 381F, 386S, 481S) *R. A. Mathon*

CSC 364S INTRODUCTION TO THE THEORY OF COMPUTATION

III – 5cs 2 – 17

Introduction to formal logic – propositional and predicate calculus. Primitive recursive functions, computable functions, recursive sets. Turning machines, unsolvable problems. Models, flowcharts, and program schemata; application to equivalence, termination, and correctness of programs. Reference: A. Yasuhara, *Recursive Function Theory and Logic*, Academic Press (Exclusion: CSC 390S as given before 1973–74. Corequisite: MAT 390S) *J. Mylopoulos*

CSC 380S SYSTEM SOFTWARE I

III – 5cs 26 – 10

Assembly language programming, job control language, and an introduction to the facilities made available by operating systems. Data structures, including linear and linked lists, stacks, queues, and trees. The principles of language processing. Parsing by precedence and LR (k) techniques. (Prerequisites: CSC 280S and ELE 353F) *E. S. Lee*

CSC 381F NUMERICAL METHODS I

III – 4 2 – 28

Roots of equations, interpolation, approximation theory, quadrature, numerical solution of ordinary differential equations. (Prerequisites: IND 202F, MAT 293F, MAT 294S. Exclusion: CSC 236S, 281F, 481S) *R. Johnston*

CSC 386S NUMERICAL METHODS II

III – 4 (elective) 2 – 28

Matrix calculations, eigenvalues, roundoff errors, random numbers, extrema of functions of several variables. (Prerequisite: CSC 381F. Exclusion: CSC 236S, 281F, 481S) *R. Johnston*

CSC 446S COMPUTATIONAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS

IV – 5cs 2 – 18

Initial value problems. Consistency, convergence, stability. Boundary value problems.

Difference schemes, finite element methods. Mixed initial boundary value problems, nonlinear problems. (Prerequisite: CSC 281F, Recommended: APM 441F)

R. A. Mathon

CSC 468F OPERATING SYSTEMS

IV – 5cs. 2 – 18

Computational structures. Processes and their cooperation; operating systems functions and facilities. Processor allocation; memory management; input-output and files; resource sharing. Correctness and reliability; protection and security. Design methodology; implementation; measurement and evaluation. (Prerequisite: CSC 380S)

D. Tsichritzis

CSC 480S SYSTEM SOFTWARE II

IV – 5cs 2 6 – 10

Development of complete software systems, with emphasis on language processors. The organization of compilers, interpreters, assemblers, and loaders; tools which facilitate their construction. The goal of precision programming, and its attainment through structured programming techniques. The laboratory associated with this course will include team projects producing pieces of system software. (Prerequisite: CSC 380S)

J. J. Horning

CSC 481S NUMERICAL METHODS

IV – 3 (elective) 3 – 1½ 10

Interpolation and approximation, numerical differentiation and integration, matrices and systems of linear equations, numerical solution or ordinary and partial differential equations, statistical methods. Text: "*Applied Numerical Methods*" by Carnahas, Luther and Wilkes, Wiley, 1969. (Prerequisites: APS 100F/S, MAT 186F, 188F, 187S, 189S. Exclusions; CSC 236S, 281F, 381F, 386S)

DEPARTMENT OF POLITICAL ECONOMY

ECO 281 ECONOMICS 2 – – 8

An introduction to the study of Economics with special reference to the problems of the Canadian economy. Those students who obtain a satisfactory term mark will not be required to write the final examination. This course has equivalent value to ECO 100 as a prerequisite for advanced courses in Economics. It may not be combined with ECO 100 or ECO 102 in any degree program.

DEPARTMENT OF ELECTRICAL ENGINEERING

ELE 121S ELECTRICITY AND MAGNETISM

I – 1, 2, 3, 4, 6, 7, 8 3 1 1 10

A basic course in electricity and magnetism including electric forces and fields, analysis of direct-current circuits, magnetic forces and fields, electromagnetic induction, and an introduction to the conductive, magnetic and dielectric properties of materials. Textbook: Shortley and Williams, *Elements of Physics, Vol. 2, 5th ed.*

ELE 150S ELECTRICITY AND MAGNETISM

1 – 5 3 – – 8

An introduction to electricity and magnetism adapted to the needs of Program 5. Elements of vector calculus. Coulomb's Law. Gauss Law. Electric field of discrete and continuous charge distributions. Potential functions. Gradient and divergence. Laplace's equation. Method of images. Forces and energy, Capacitance. Forces on moving charges and conductors. Ampere's Law. Biot-Savart Law. Magnetic field of rings and coils. Faraday's Law and applications. Self and mutual inductance. Energy stored in a magnetic field. Alternating current circuits: series and parallel. Electric and magnetic fields in matter. Textbook: Duckworth, *Electricity and Magnetism*, Holt, Rinehart, Winston.

ELE 200F COMPLEX VARIABLES AND VECTOR CALCULUS

II – 7 3 – 28

Functions of several variables. Partial Differentiation of implicit functions. Maxima, minima. Applications to curve fitting of nonlinear problems. Differentiation of vector functions. Gradient, divergence and Gauss Theorem. Curl of a vector field and Stokes' Theorem. The operator Del. Applications to Electromagnetic Fields, Maxwell's equations. Theory of Complex Variables, Cauchy-Riemann Equations. Complex integrals. Cauchy's integral theorem and formula. Taylor and Laurent series. Residues. Conformal Mapping and their applications to two-dimensional potential problems. Applications of Complex Integrals to stability of systems. Textbook: Pennisi, *Elements of Complex Variables,* Holt, Rinehart, Winston 1963. (Prerequisite: MAT 187S, 189S, corequisite: MAT 290F).

ELE 201S NUMERICAL AND PROBABILISTIC METHODS

II – 7 3 – 28

Errors in computation; significance of results in view of physical models. Iterative techniques for solving non-linear equations. Zeros of polynomials; transfer functions of electrical systems. Characteristic value problems; natural frequencies of physical systems. Interpolation; curve fitting; processing of experimental data. Numerical integration. Ordinary differential equations; systems of differential equations as models of electrical and other physical systems. Elementary probability concepts in engineering. Conditional probability; probability of causes. Random variables and functions; electrical noise. Mean and variance of random variables. Discrete distributions: binomial. Poisson, as they are in physical systems. Continuous distributions: uniform, exponential, normal. Life testing; expected performance; selectivity. Central limit theorem; physical supply networks. Sampling and statistics. Estimation of parameters. Hypothesis testing. All topics are illustrated with examples from engineering practice, accompanied by corresponding computational design exercises. (Prerequisite: MAT 290F)

ELE 210F CIRCUIT THEORY I

II – 7 3 1½ 1 9

Circuits as models for physical devices; relationships between circuit and field concepts. Elementary network theorems and laws. Transient response of circuits. Topology. Loop and nodal analysis. Response to complex frequency excitation. General solution of linear differential equations with constant coefficients. Steady-state response with direct and sinusoidal sources including analysis of polyphase circuits. The laboratory provides an introduction to techniques of electrical measurements. Textbook: Close, *The Analysis of Linear Circuits*. (Prerequisite: ELE 121S, corequisite: MAT 290F)

ELE 211S CIRCUIT THEORY II

II – 7 3 1½ 1 9

Complex frequency, network functions, poles and zeros, frequency response, the S plane. Resonance phenomena. Magnetically coupled circuits. Impedance transformations. Two-port networks. General network theorems. Transfer functions. Orthogonal functions and the Fourier series and transforms. Linear systems. Pole zero plots. Textbooks: Close, *The Analysis of Linear Circuits*; Lathi, *Signals, Systems and Communications*. (Prerequisite: ELE 210F, ELE 200F)

ELE 221S ELECTRIC AND MAGNETIC FIELDS

II – 7 3 – 2 8

Static electric and magnetic fields. Properties of dielectric and magnetic media. Particle dynamics in electric and magnetic fields. Time-varying fields. Development of Maxwell's equations and interpretation. Textbook: Hayt, *Engineering Electromagnetics*. (Prerequisites: ELE 200F, ELE 210F, MAT 290F)

ELE 231S ELECTRONIC CIRCUITS A

II – 7 2 1½ 1 8

A global view of electronics and electronic systems considering the following topics: The ideal diode. Vacuum tubes, semiconductors, PN junctions. Bipolar transistors. DC amplifiers. Large signal switching. Textbook: Oldham, Schwartz, *An Introduction to Electronics*, Holt, Rinehart, Winston, 1972. (Prerequisite: ELE 210F, MMS 221F, corequisite: ELE 211S)

ELE 250F ELECTRIC CIRCUITS

II – 5 3 3 – 8½

Direct current circuits. Ideal circuit elements. Alternating current circuits and the use of phasors. The use of complex numbers in sinusoidal analysis. Introduction to the theory of transients. Reduction methods and network theorems. The frequency characteristics of elementary circuits. The harmonic analysis of alternating quantities. Techniques of transient analysis. Textbook: G. W. Carter, A. Richardson, *Techniques of Circuit*

Analysis, Cambridge Univ. Press, 1972. (Prerequisite: ELE 150S, corequisite: MAT 295F)

ELE 270F CIRCUIT THEORY AND MEASUREMENTS

II – 3 3 1½ 1½ 10

Experimental laws. Techniques of circuit analysis. Duality. Source-free RL and RC circuits. The unit-step forcing function. The sinusoidal function. Phasors. The sinusoidal steady-state response. Average power and rms values. Polyphase circuits. Magnetically-coupled circuits. Textbook: Hayt, Kemnerly, *Engineering Circuit Analysis*, McGraw-Hill 2nd ed. (Prerequisite: ELE 121S)

ELE 271S ELECTRICAL ENGINEERING

II – 4, III – 4 (elective) 3 1½ 1 8

Analysis of single phase and three-phase circuits; principles of ac and dc machines; introduction to vacuum-tube and solid-state devices; basis of digital computation and analogue simulation; electronic measurements applied to industrial processes. (Prerequisite: ELE 121S or ELE 150S or equivalent)

ELE 272s ELECTROMECHANICAL ENERGY CONVERSION

II – 3 3 1½ 1½ 8

Ferromagnetism and magnetic circuits. The transformer. Principles of electromechanical energy conversion. Actuators. Steady-state operation of dc and ac machines. (Prerequisite: ELE 270F)

ELE 310F SYSTEM AND SIGNAL ANALYSIS A

III – 7 3 – 2 9

System representation and analysis. State variable formulation. Review of Fourier series, Fourier transform, and Laplace transform. A study of the behaviour of continuous-time linear systems using transform methods. Transfer functions, frequency response, Bode diagrams, energy density spectrum. Stability, Routh-Hurwitz, Nyquist, root locus. Signal flow graphs. Textbooks: Lathi, *Signals Systems and Communications*; Dorf, *Modern Control Systems*. (Prerequisite: ELE 211S)

ELE 311S SYSTEM AND SIGNAL ANALYSIS B

III – 7 3 1½ 1 9

Convolution integral and methods. Communication systems, multiplexing, modulation, and sampling. Stochastic processes, stationary, convolution, correlation, power spectrum, spectral analysis. Textbook: Lathi, *Signals, Systems and Communications*; Davenport, *Probability and Random Processes*. (Prerequisite: ELE 310F)

ELE 312F ELECTROMECHANICAL SYSTEMS I

III – 7 3 1½ 1 9

Electromechanical energy conversion principles. Magnetic circuit analysis. Modelling of linear and non-linear magnetic systems. Single phase and polyphase transformers. Transformer design. Introduction to rotating machines. Textbooks: Slemon, *Magneto-Electric Devices*; Fitzgerald, Kingsley, Kusko *Electric Machinery*, 3rd ed. (Prerequisite: ELE 211S, corequisite: MEC 205F)

ELE 313S ELECTROMECHANICAL SYSTEMS II

III – 7 3 1½ 1 9

Generalized machine parameter evaluation, reduction. Steady-state and dynamic performance of DC, induction and synchronous machines. Introduction of multi-machine systems. Textbooks: Slemon, *Magneto-Electric Devices*; Fitzgerald, Kingsley, Kusko, *Electric Machinery*. (Prerequisite: ELE 312F)

ELE 314S DIGITAL SYSTEMS

III – 7; III – 5e (elective) 2 1½ – 6

Introduction to logic, propositional logic, Boolean algebra, basic operations, truth tables, fundamental algebraic manipulations. Storage elements, flip-flops and registers, register transfer operations. Design of counters, encoders, decoders. Fan-in, fan-out. Number representation and coding, 1's and 2's complement, BCD, parity. Designs for adders, multipliers, dividers. Memory techniques, read/write, read only, volatile, non-volatile magnetic core memory. Design methods for control and data flow in simple systems such as sampled data communications, feedback digital controller. Textbook: T. L. Booth, *Digital Networks and Computer Systems*. (Prerequisite: ELE 201S, ELE 231S or equivalent)

ELE 320F FIELDS AND WAVES

III – 7 2 1½ 1 8

Propagation of plane waves. Reflection of waves at plane boundaries. Guided waves. Transmission line theory. Smith chart. Radiation from antennas. Diffraction and scattering. Introduction to holography. Textbook: Skilling, *Fundamentals of Electric Waves*. (Prerequisite: ELE 221S)

ELE 331S ELECTRONIC CIRCUITS B

III – 7 3 3 – 10

Ideal amplifiers: characterization and applications. Ideal Diodes: applications, JFET and MOSFET: mechanisms, models and applications. Biasing: passive, active and reactive loads; distortion, power dissipation. Junction diodes and transistors: properties, models and applications. Biasing: operating point stability, thermal runaway. Frequency effects; gain calculations; Miller effect. Differential amplifiers; Operational amplifiers; Multistage amplifiers; Negative feedback. Textbooks: Millman and Halkias, *Integrated Electronics*. Angelo, *Electronics: BJT's. FET's, and Microcircuits*. (Prerequisite: ELE 231S, corequisite: ELE 336S)

ELE 335F PHYSICAL ELECTRONICS A

III – 7; III – 8 (elective) 2 ¾ ¾ 6

Introductory quantum mechanics leading to the band theory of solids. Emission phenomena. Structure and basic properties of semiconductors. Hole and electron densities: impurities; generation and recombination processes. Carrier transport: the continuity equations. Semiconductor diodes: theoretical and practical aspects of p-n junction, metal-semiconductor and other diode types. (Prerequisite: MMS 221F, ELE 231S).

ELE 336S PHYSICAL ELECTRONICS B

III – 7 2 – 1½ 6

Unipolar transistors; junction gate, M.I.S., and other surface devices: theory and circuit models. Bipolar transistors: fundamental theory, injection efficiency, base transport efficiency, small-signal low-frequency models. Charge storage models. High-frequency, small-signal analysis circuit models. PNPN devices. Fundamentals of integrated circuits: fabrication theory and technology: diffusion, epitaxy, oxide masking; capacitors, resistors, bipolar and unipolar transistor integration. Photoelectronics, solid-state optoelectronic phenomena: photoconductive and pn junction radiation detection. Image orthicon, vidicon, image storage and intensification. (Prerequisite: ELE 335F)

ELE 350F PHYSICAL ELECTRONICS I

III – 5cs, 5e; 5p, 8 (elective) 2 ¾ 1 7

Courses 350F and 352S deal with the basic physics underlying the operation of semiconductor devices. Band theory of solids, metals, semiconductors, insulators, mobility and conductivity. Drift and diffusion currents. Theory of pn junctions. Tunnel and avalanche diodes. Theory and operation of bipolar transistors. (Prerequisite: PHY 281S, exclusion: ELE 335F)

ELE 351F ELECTRONIC CIRCUITS I

III – 5cs, 5e; 5p (elective) 2 1½ – 8

A communication system, an analog computer and digital computer, as examples of electronic systems. Identification of basic circuit functions. Passive RLC circuits as load and coupling circuits in both the time and the frequency domain. Ideal active elements: Amplifiers, operational amplifiers, controlled sources, logic elements and memory elements. Nonideal behaviour of amplifiers and their classification. Ideal and real diodes with applications. Qualitative description of pn junctions. Characteristics of bipolar transistors in the normal mode. Biasing design of transistor circuits. Derivation of 1st order equivalent circuits. Design of simple transistor amplifier circuits. Textbook: Millman and Halkias, *Integrated Electronics*, McGraw-Hill, 1972. (Prerequisite: ELE 250F, exclusion: ELE 231S)

ELE 352S PHYSICAL ELECTRONICS II

III – 5e; 5p (elective) 2 ¾ 1 7

Small signal model, circuit configurations and applications of the bipolar transistor.

Theory of junction and MOS field effect transistors; small signal models. Theory and applications of switching devices: pnpn diode, silicon-controlled rectifiers, triacs, unijunction transistor. Fundamentals of integrated circuits. (Prerequisite: ELE 350F, exclusion: ELE 336S)

ELE 353F COMPUTER ORGANIZATION

III – 5cs; IV – 5e (elective) 3 1½ 1 10

Digital system design principles. Registers and data flow. Computer structure, machine language instruction execution and sequencing, addressing techniques. Digital representation of data. Arithmetic operations. Memory hierarchy, direct and associative addressing. I/O techniques and channels. Some case studies of actual machines. Introduction to reliability. The laboratory will consist of topics from simulation studies of systems using GPSS, experiments involving logic systems, and small computers. Textbook: Lewin, *Theory and Design of Digital Computers*. (Exclusion: ELE 441S)

ELE 354S ELECTRONIC CIRCUITS II

III – 5e 3 3 – 10

Design of AC coupled transistor stages, DC amplifier. Integrated circuit design limitation. Design of multitransistor circuits from configuration point of view. Hybrid-Pi equivalent circuit models. Design of audio amplifiers, wideband amplifiers, tuned amplifiers. Negative feedback concepts and oscillators. Field effect devices and applications. Transistors as switching elements. Design of simple logic and memory circuits. Textbook: Millman and Halkias, *Integrated Electronics*, McGraw-Hill, 1972. (Prerequisite: ELE 351F, exclusion: ELE 331S)

ELE 355F SYSTEM AND SIGNAL ANALYSIS I

III – 5cs, 5e 3 – 18

Signal representation by classical Fourier series and Fourier integral: orthogonality and completeness, pointwise and mean square convergence, inversion techniques, energy relations and time-bandwidth trade-off. Applications to circuits, sampling and modulation. Laplace transform: inversion techniques, application to transient analysis and frequency response of systems described by ordinary differential and differential-difference equations. Additional topics selected from: distributions, z-transform, discrete Fourier transform. (Prerequisite: ELE 250F, MAT 295F, MAT 289S, or equivalent. Most assignments require use of the computer. Exclusion: ELE 310F)

ELE 356S SYSTEM AND SIGNAL ANALYSIS II

III – 5e 3 1½ – 8

Modelling of physical systems. State representation of dynamic systems as vector matrix differential and difference equations. Linearization. Controllability and observability. Steady-state performance and stability analysis for constant, linear systems employing Bode diagrams, root loci, Routh and Nyquist criteria. Synthesis of elementary feedback compensators. (Prerequisite: ELE 355F)

ELE 357F ELECTROMAGNETIC FIELDS

III – 5e, 5g; 5p (elective) 3 1½ 1 9

Wave propagation in linear electromagnetic media. Maxwell's equations and constitutive relations. Plane waves in dielectric and conducting media. Wave polarization. Poynting vector. Transmission lines. Smith Chart. Dielectric and optical waveguides. Retarded potentials. Small loop and short dipole antenna. Wave propagation in anisotropic media. (Prerequisite: ELE 221S, PHY 280F, MAT 289S)

ELE 358S CONTROL SYSTEMS

III – 5a, 5nt; 5p (elective) 3 1½ 1 9

As prescribed for ELE 356S. The tutorial will be used to provide problem solving competence in a few of the topics missing in the background of registrants who have not taken ELE 355F. (Prerequisite: ELE 250F)

ELE 360S ELECTRONIC CIRCUITS II

III – 5cs 3 1½ – 8

As prescribed for ELE 354S with special laboratory exercises.

ELE 405F SWITCHING THEORY

IV – 7 (elective) 2 – 2 8

Boolean algebra, boolean functions. Design and minimization of combinational networks. Sequential machines, finite state models, synthesis, state assignment, state reduction. Synthesis and analysis of asynchronous sequential machines. Combinations of sequential machines. Identification. Textbook: Kohavi, *Switching and Automata Theory*. (Prerequisite: ELE 314S)

ELE 410F CONTROL SYSTEMS I

IV – 7 (elective) 2 1½ 1 8

Review of steady-state and dynamic performance analysis, stability analysis and Bode diagrams. Linear compensation design. Process control design. Frequency and time domain analysis of nonlinear controllers; design of real control systems. (Prerequisite: ELE 311S)

ELE 411S CONTROL SYSTEMS II

IV – 7 (elective) 2 1½ 1 8

Vector-matrix differential equations as models for physical systems. Solution methods; analytic, analog and digital simulation. Eigenvalues, eigenvectors; modal theory. Controllability; design of modal controllers. Observability; design of dynamic observers. Design using optimal control methods. (Prerequisite: ELE 410F, exclusion: ELE 450F)

ELE 412F NETWORK THEORY

IV – 5e, 7 (elective) 3 – 2 8

Network and analysis network functions. Introduction to active filters. Properties and synthesis of LC and RC one-ports. Positive real functions, testing, realizations. Properties and synthesis of lossless singly- and doubly-terminated two-ports. Synthesis of approximations to ideal filters. Textbook: Humphreys, *The Analysis, Design and Synthesis of Electrical Filters*. (Prerequisite: ELE 311S, ELE 201S)

ELE 413F POWER SYSTEM ANALYSIS

IV – 7 (elective) 2 1½ 1 8

Identification of the power system. Transmission lines, parameters and representation. Synchronous machines and other power system components. Behaviour of elementary power systems under fault conditions. (Prerequisite: ELE 313S)

ELE 414S POWER SYSTEM CONTROL

IV – 7 (elective) 2 1½ 1 8

Control of power and frequency. Control of voltage and reactive power. Load flows. Stability limits. Underground transmission. Direct current transmission. Overvoltages and insulation requirements. Protection. Textbook: Weedy, *Electric Power Systems*, 2nd ed., John Wiley and Sons 1970. (Prerequisite: ELE 413F)

ELE 416F COMMUNICATION SYSTEMS A

IV – 7 (elective) 2 3 – 8

Spectral analysis, use of Fast Fourier Transforms for simulation, random variables and processes, AM and FM systems, vestigial side band, single side band, noise in modulation systems. Textbook: Taub and Schilling, *Principles of Communication Systems*, McGraw-Hill. (Prerequisite: ELE 311S)

ELE 419 ELECTROMECHANICAL SYSTEMS III

IV – 7 (elective) 2 1½ 1 8

Steady state and dynamic operation of both AC and DC industrial drive systems. Design of conventional and solid state control including position velocity and torque control applications. System monitoring and protection including central computerized control. Introduction to elementary machine and machine system design. Textbook: Kusko, *DC Machine Drive Systems*; Jones, *Unified Machine Theory*. (Prerequisite: ELE 313S, corequisite: ELE 410F)

ELE 420F ELECTROMAGNETIC THEORY

IV – 7 (elective) 2 – 2 8

Radiation from wire antennas, antenna and continuous current distributions. Wave scattering. Antenna system design. Wave polarization. Waveguide resonators. Circular waveguides. Reciprocity. Self and mutual impedance of current-carrying conductors. Wave propagation in the ionosphere. Textbook: Jordan and Balmain, *Electromagnetic Waves and Radiating Systems* 2nd ed. (Prerequisite: ELE 320F)

ELE 421S MICROWAVES AND OPTICS

IV – 7 (elective) 2 1½ 1 8

Propagation of waves in single and multiple dielectric films. Antenna arrays. Micro-wave communication systems. Formal solution of boundary value problems; Green's functions. Scattering by conductors. Diffraction by apertures. Fourier optics and holography. (Prerequisite: ELE 320F)

ELE 430F ELECTRONIC CIRCUITS C

IV – 7 (elective) 2 3 – 8

A design course considering the following topics: Bias design. AC and DC coupling techniques. Multistage amplifiers. Feedback. Frequency effects. Narrow band amplifiers. Oscillators. Active filters. Modulation/Demodulation. Power amplifiers. Low noise Techniques. Textbook: Millman and Halkias, *Integrated Electronics*; Ghausi, *Electronic Circuits*. (Prerequisite: ELE 331S, ELE 311S, ELE 311S)

ELE 431S INTEGRATED CIRCUITS

IV – 7, 5e (elective) 2 3 – 8

Design of integrated circuits with particular emphasis on the interaction between device and circuit design. Linear integrated circuit design techniques and limitations. Digital integrated circuits design evolution leading to large scale integration. (Prerequisite for IV – 7: ELE 336S, ELE 331S; for IV – 5e: ELE 352S, ELE 354S)

ELE 432S SWITCHING CIRCUITS

IV – 5cs; IV – 7, 5e (elective) 2 3 – 8

A design course in electronic switching circuits. Static and dynamic characteristics of semiconductor devices as switching elements. Transistor multivibrators. Integrated circuit logic families. Linear and non-linear waveshaping techniques. Flip-flops, registers, counters, encoders, memories. (Prerequisite for IV – 7: ELE 314S, ELE 331S; for IV – 5: ELE 354S, ELE 314S)

ELE 433S POWER SEMICONDUCTOR CIRCUITS

IV – 7, 5e (elective) 2 3 – 8

Circuits with switches and diodes, power semiconductor switches, types of communications, AC voltage controllers, controlled rectifiers, DC to DC converters, inverters, applications to motor control, logic and control circuits. (Prerequisite: ELE 331S, ELE 314S)

ELE 435F SEMICONDUCTOR ELECTRONICS

IV – 7, 5e (elective) 2 1½ 1 8

This course is concerned with practical aspects of semiconductor devices. PN junctions, bipolar transistors, MOSFETs, JFETs, light emitting diodes, and other important devices will be discussed. Such topics as noise, high and low level injection, temperature and high frequency limitations, recombination and generation associated with these devices will be considered. (Prerequisite: ELE 336S or ELE 352S)

ELE 437S QUANTUM ELECTRONICS

IV – 7 (elective) 3 1½ – 8

The purpose of the subject is to introduce the student to the principles and techniques underlying the operation and design of the maser and laser type devices, and their use in communication, remote sensing and measurement systems. The initial part of the course is devoted to the introduction to the basic concepts of quantum mechanics and their use in the description of the mechanism of radiation emission and absorption. The concepts developed are then applied to the design and description of masers in the optical, infrared and microwave frequency ranges. Textbook: H. G. Unger, *Introduction to Quantum Electronics*, (Prerequisite: ELE 320F, ELE 336S)

ELE 440F COMPUTER PROGRAMMING AND DATA STRUCTURE

IV – 7, 5e (elective) 2 – 2 8

Review of machine structure and machine language programming. Assembler language. Assembler design, searching and sorting. Macro language and macro processors. Design of loaders. High level languages: PL/I. Formal systems: formal grammars, BNF. Compiler design. Operating systems. Textbook: Donovan, *Systems Programming*. (Prerequisite: ELE 314S or equivalent)

ELE 441S COMPUTER ORGANIZATION

IV – 7, 5e (elective) 2 3 – 8

The design of digital computers including the following topics: Control unit organization: series-parallel operation, control unit logic, micro-programmed control units. Arithmetic units: addition, subtraction, multiplication, division, floating point arithmetic. Storage systems: core memory, semiconductor memory, drums, discs, tapes, associative memory. I/O: control paper tape, I/O organization. High parallel systems: pipeline systems, array processors. Textbook: Lewin, *Theory and Design of Digital Computers*. (Prerequisite: ELE 314S, exclusion: ELE 353F)

ELE 445S BIOMEDICAL ENGINEERING

IV – 7, 5e (elective) 3 1½ – 8

An introduction to some aspects of the interaction between engineering and medicine, given by the staff of the Institute of Bio-Medical Electronics and Engineering: Basic Anatomy and Physiology, Biological communication processes, Biological feedback and control, Bio-medical instrumentation, Cardiovascular measurements, Radiation diagnosis. Textbook: Selkurt, *Physiology*. (Prerequisite: ELE 331S and ELE 310F or equivalent)

ELE 447S ILLUMINATION

IV – 7 (elective) 3 1½ – 8

The course deals in general with the engineering problems which relate to the effective use of light (physical, physiological and psychological) in the everyday life of man. The topics covered include: the nature and characteristics of light; the production of light: incandescence and luminescence; the human eye, visual processes, and visual phenomena; radiometric and photometric units and laws; photometric measurements; calculation of photometric quantities; design of the visual environment: principles which relate to visual comfort and efficiency; colour and colorimetry; light sources – circuits and controls; visual problems at low light levels e.g. street lighting. Textbook: Stevens, *Building Physics-Lighting*.

ELE 448F APPLIED OPTICS

IV – 7 (elective) 2 1½ 1 8

Principles of ray optics and their applications to the design and analysis of optical systems including the theory of aberrations. Wave optics of isotropic and anisotropic media, interference phenomena and diffraction limits of optical systems. Textbook: M. V. Klein, *Optics*, Wiley. (Prerequisite: ELE 320F)

ELE 449F ENGINEERING AS A PROFESSION

IV – 7 (elective) 2 – – 8

The course will consist of a combination of lectures and seminars on the role of the Engineer in society. Topics to be discussed include: 1. Why does society not yet consider the engineer to be fully professional? 2. Does the engineer have a proper set of values? 3. Why does there not exist a philosophy of engineering? 4. Should the engineer bear the sole responsibility for the social consequences of his engineering projects? 5. What is the role of the engineer in such public issues as pollution, unemployment, urban development, etc? 6. The role of the engineer as an entrepreneur.

ELE 450F TECHNIQUES OF SYSTEM THEORY

IV – 5e (elective) 2 1½ – 8

An advanced undergraduate course in multivariable system theory. Linear differential equations over linear spaces. System theory fundamentals of constant and time-varying dynamic systems, representations and realizations, equivalence, maps, controllability, observability. Stability concepts, bounded and in the sense of Lyapunov, perturbation results. Computational methods. Applications such as pole assignment, observer theory, vector frequency response methods. Textbook: Desoer, *Notes for A Second Course on Linear Systems*. (Prerequisite: ELE 356S, ELE 358S or ELE 311S with good standing)

ELE 452F ELECTRONIC CIRCUITS III

IV – 5e (elective) 2 3 – 8

A design course in electronic circuits including: Multistage amplifiers. Feedback amplifiers. Oscillators. Wideband amplifiers. Tuned amplifiers. Low noise amplifiers. Power amplifiers. Active filters. Use of functional electronic building blocks, e.g., operational amplifiers, multipliers, phase locked loops, etc., in instrumentation applications. Computer aided circuit design is used throughout the course. (Prerequisite: ELE 352S, ELE 354S, exclusion: ELE 430F)

ELE 453F COMMUNICATION SYSTEMS I

IV – 5cs; 5e (elective) 2 1 – 8

Spectral analysis, use of Fast Fourier Transforms for simulation. Random processes. AM and FM systems. Vestigial side band. Single side band. Pulse modulation systems. Noise in modulation systems. Textbook: Taub and Schilling, *Principles of Communication Systems*, McGraw Hill. (Prerequisite: ELE 356S, exclusion: ELE 416F)

ELE 454S COMMUNICATION SYSTEMS II

IV – 5e, 7 (elective) 2 3 – 8

Pulse modulation systems, delta modulation, noise in pulse modulation systems, phase locked loops, data transmission, matched filters, information theory and coding. The laboratory will include design projects. (Prerequisite: ELE 416F or ELE 453F)

ELE 455S TECHNIQUES OF OPTIMIZATION

IV – 5cs; 5e (elective) 3 – 1 8

Calculus of variations. Maximum Principle. Linear and non-linear mathematical programming; dynamic programming; queuing theory; some problems in control theory; Monte Carlo methods. Applications will be drawn from engineering practice. (Prerequisite: APM 393F)

ELE 457S MICROWAVE ELECTRONICS

IV – 7, 5e (elective) 2 1½ 1 8

Design principles of microwave devices with the following topics: Stability criteria for active electromagnetic systems. Wave interaction in active media: Gunn diodes, IMPATT diode, Solid-state lasers. Coupled Systems: Travelling wave tube, backward wave oscillator, acousto-electric amplifier. Parametric Interactions: harmonic generation and mixing, parametric amplifiers. Microwave acoustics: bulk wave transducers, acousto-optic modulator. Passive components: resonators and couplers. (Prerequisite: ELE 320F or ELE 357F)

ELE 459F SWITCHING THEORY

IV – 5cs; 5e (elective) 2 – 1 7

Design of combinational switching circuits. Minimization techniques. Functional decomposition. Threshold networks. Iterative arrays. Finite state sequential machine model. Design of synchronous and asynchronous machines. Sequential machine decomposition.

Linear sequential machine applications. Textbook: Z. Kohavi, *Switching and Finite Automata Theory*, McGraw-Hill.

ELE 470F ELECTRICAL SYSTEMS

IV – 8; 2B (elective) 3 3 – 9

Electrical circuits, components, machines, sensors, transducers, instrumentation and controls with emphasis on practical applications, including heating and melting. Textbook: Lister, *Electric Circuits and Machines* (4th ed.).

ELE 471F INSTRUMENTATION DESIGN

IV – 3 (elective) 3 1½ – 10

This course includes the theory, methods, and instrumentation required for the measurement of variables of interest to mechanical engineers; e.g., strain, liquid flow, air-flow, vibration, etc. Also included is a discussion of transducers required to convert these variables to electrical signals, and the use of electronic modules in the design of equipment to process these signals. The interfacing of these modules with analogue and digital recording and processing devices will also be covered.

ELE 496F THESIS

IV – 7 – – – 16

Each student in Electrical Engineering is required to write a thesis on an approved topic of his choice under the supervision of an academic staff member of the department. The thesis may involve experimental or other project-related activities. The weight to be attached to the thesis depends on the size of the thesis topic and must be approved by the student's thesis supervisor. Further details are available from the Electrical Engineering Enquiry Office, G.146. (Prerequisite: completion of all Third Year technical courses. Exclusions: ELE 497S, ELE 598F, ELE 499S)

ELE 497S THESIS

IV – 7 – – – 16

Same as ELE 496F, but in spring term. (Prerequisite: completion of all third year technical courses, Exclusions: ELE 496F, ELE 498F, ELE 499S)

ELE 498F THESIS

IV – 7 – – – 8

Same as ELE 496F, but of smaller weight. (Prerequisite: completion of all third year technical courses, exclusions: ELE 496F, ELE 497S)

ELE 499S THESIS

IV – 7 – – – 8

Same as ELE 498F but in spring term. (Prerequisite: completion of all third year technical courses. Exclusions: ELE 496F, ELE 497S)

DEPARTMENT OF ENGLISH

ENG 281F/S EFFECTIVE WRITING 2--8

An "effective" writer knows how to express his ideas clearly and precisely, how to employ the laws of logic in ordering and supporting an argument, and how to use language persuasively. This course will involve discussion of the theory and method of various kinds of writing supplemented by close consideration of examples of effective prose and by frequent and varied practical exercises designed to develop writing skills.

ENG 282F/S TWENTIETH-CENTURY LITERATURE 2--8

This course provides an introduction to twentieth-century literature through a study of representative works of important playwriters, poets, novelists and short-story writers.

ENG 283F/S CANADIAN LITERATURE 2--8

This course will deal with representative works of Canadian poets, novelists, short-story writers and essayists, and will consider some of the historical and cultural forces that helped to shape the Canadian imagination.

ENG 284F/S VARIETIES OF FICTION 2--8

This course is designed to increase enjoyment and understanding of the various forms of prose fiction (the novel, the novella, the short-story) through close consideration of representative works, including some recently written materials.

ENG 285F/S DRAMA AND THE MODERN THEATRE 2--8

This course is designed to increase understanding and enjoyment of drama. It will deal with plays (of whatever period) which are still being performed in the contemporary theatre and will consider the reasons for their theatrical effectiveness for modern audiences. Where possible, attention will be given to filmed drama and to plays currently being performed in Toronto.

ENG 286F/S LITERATURE AND SCIENCE 2--8

This course will explore some of the ways in which the methods and discoveries of science have made and are making an impact upon literature and will deal with a selection of the wide variety of works (from metaphysical poetry to science fiction) which were written in response to the scientific and technological ideas of their time.

ENG 287S SPECIAL STUDIES IN ENGLISH 2--8

A course intended for students in ENG 281F, 282F, 283F, 284F, 285F or 286F who may wish to continue studying the subject matter of their Fall-Term course rather than select a different option. (Prerequisite: Consent of the instructor.)

DIVISION OF ENGINEERING SCIENCE

ESC 495, 496, 497, 498F, 498S, 499 THESIS

IV–5

Every student in Fourth Year Engineering Science is required to prepare a thesis on an approved subject. Instructions concerning the thesis requirements are issued during the Spring Term of Third Year, and copies may be obtained in the division office. The weight allocated in each term of each option is shown in the Fourth Year curriculum. The full year theses will be graded after submission in the Spring term, and the grade included in the weighted average for that term only. The weight assigned will be the sum of the weights for both terms.

DEPARTMENT OF GEOGRAPHY

GGR 311S SEDIMENTARY PROCESSES

IV – 2A, 2C (elective) 11 – 6

Basic processes of sediment erosion, transportation, and deposition that operate during landscape evolution. Principles of clastic sedimentation, origin of sedimentary particles, particle properties, behaviour of particles in fluids, primary sedimentary structures, sedimentary sequence. Tectonics and sedimentation, geosynclines, continental geomorphology. Modern and ancient depositional environments, environment determination, facies analysis, palaeogeography. Analytic techniques used in sediment studies.

DIVISION OF GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

GLE 201S TOPICS IN GEOLOGICAL ENGINEERING

II – 2 2 – 27

A survey course to acquaint students with engineering problems and their solution in areas of the three options in the program and to inform the student of the type of engineering in which they might be engaged in professional practice. The time in the course is divided equally among the Department of Geology, the Department of Metallurgy and Material Science, and the Department of Civil Engineering.

Co-ordinator: *F. A. DeLory*

GLE 328F MINING TECHNOLOGY I

III – 2B; 2A (elective) 3 – 18

An introduction to mining practice, and its basic unit operations and processes; including drilling and blasting, acquisition of mineral lands. Sampling theory and practice provide background for future evaluation problems.

GLE 329S MINING TECHNOLOGY II

III – 2A, 2B (elective) 3 – 18

Mine layouts and principal mining methods as applied to geological situations and stress environments. Further study of cost-making factors, including transportation, mine hoisting. Introduction to mine-smelter relationships, and other economic aspects. (Prerequisite: GLE 328F)

GLE 426F MINE OPERATION AND ADMINISTRATION I

IV – 2A, 2B (elective) 2 – 3 8

Operational, financial, legal, and economic considerations in the valuation and management of mineral enterprise. Laboratory work is given on a progressive problem in the estimation of grade and tonnage in an ore situation. While GLE 328F is not a prerequisite, a knowledge of its content would be useful.

GLE 427S MINE OPERATION AND ADMINISTRATION II

IV– 2A, 2B (elective) 2 – 3 8

A continuation of the subject matter of GLE 426F. In the laboratory the problem evaluated in GLE 426F is pursued through the selection of optimum mining rate and the design of enterprise, complete to the point of financing. (Prerequisite: GLE 426F)

GLE 492S, 493, 494S, 495, 496S THESIS

IV – 2

Every student in fourth year Geological Engineering and Applied Earth Science is required to prepare a thesis on an approved subject. The Option A thesis (GLE 492S) is a Spring Term thesis and topics are normally submitted for approval in the fall term with the work being done in the spring term under the supervision of a faculty member. For Option B, the thesis will normally involve experimental as well as other project related activities and will generally be done throughout both Fall and Spring terms. A shorter one-term thesis (GLE 494S) may be selected with the approval of the thesis supervisor. For Option C the thesis is normally a Spring Term thesis (GLE 496S) with the topic submitted for approval in the fall term and the work done in the Spring Term under the supervision of a faculty member. With the permission of the Chairman of the Division a 16 unit thesis extending through both terms (GLE 495) may be taken.

DEPARTMENT OF GEOLOGY

GLG 120F PRINCIPLES OF PHYSICAL GEOLOGY

III – 5g; II – 2 (elective) 2 2 1 9

Principles of physical geology and the evolution of the earth as a planet. Topics include the composition and form of minerals and rock bodies, the deposition of sediments by rivers and oceans, the origin of mountain systems and the development of global structures. Air photographs, geological maps and cross sections are used in studying the effects of geologic processes. A field trip is taken in October. (Fall Term of Arts and Science GLG 120) (Exclusion: GLG 180F) *E. W. Nuffield*

GLG 122S PRINCIPLES OF HISTORICAL GEOLOGY

II – 2, III – 5g 2 2 1 9

A lecture-laboratory course that traces the history of the earth and its changing environment from the sequence of physical and biological events revealed in the rock record. Paleontology and concepts of geologic environments and time are emphasized in the laboratory and in the field. (Spring Term of Arts and Science GLG 120) (Prerequisite: GLG 180S or 120F) *G. Norris*

GLG 180S APPLIED PHYSICAL GEOLOGY

I – 1, 2, 3, 4, 5, 6, 7, 8 (elective) 3 1½ – 8

Fundamentals of physical geology as related to engineering problems and practice. Configuration of the planet and the effects of external and internal processes that act upon it; influence of earth processes as a factor in the design of engineering structures. Students will gain a knowledge of earth materials, their occurrence and uses. (Exclusion: GLG 120F) *S. D. Scott, A. J. Naldrett*

GLG 220 INTRODUCTORY MINERALOGY AND PETROLOGY

II – 2 2 3 – 9

In the Fall Term mineralogical concepts, optical mineralogy and important rock forming minerals are reviewed. The Spring Term gives an introduction to the classification, occurrence and genetic processes of igneous, metamorphic and sedimentary rocks. Laboratories include crystallographic exercises, mineral optics, and the study of rocks and minerals in the microscope and hand specimen. (Prerequisite: CHM 100F, pre or corequisite: GLG 120F/180S, GLG 122S) *J. C. Rucklidge*

GLG 280S APPLIED PHYSICAL GEOLOGY

II – 1 2 1½ 1 8

A course similar to GLG 180S, but with alternate laboratory assignments.

GLG 315F FIELD TRIP

III – 2 – – – 6

A field course that must be taken by all students in Geological Engineering and Applied Earth Science. This is an 8 day field camp in the Northern Appalachians emphasizing elementary mapping methods and basic field techniques applicable to structural-stratigraphic studies. The Taconian orogenic belt in Quebec and the adjacent craton will be examined in the field as a prelude to more intensive study and laboratory work in 300-series courses. (Prerequisite: GLG 220) A fee, currently $50, is charged to cover part of cost of transportation and accommodation.

GLG 320 PETROLOGY

III – 2A, 2B 23 – 8, 23 – 8

The principles of igneous, sedimentary and metamorphic petrology with major emphasis on examination of criteria used for the classification of major rock types; the interpretation of rocks as indicators of crustal and mantle processes. Laboratory work covers the application of mineralogical data to the identification and description of igneous, sedimentary and metamorphic rocks. (Prerequisite: GLG 220) *J. J. Fawcett*

GLG 321F STRATIGRAPHY AND SEDIMENTATION

III – 2A, 2C 13 – 8

The properties and classification of sediments and strata. Sedimentary environments and tectono-environmental concepts in stratigraphy; the influence of global tectonics on local stratigraphy. Stratigraphy applied to mineral exploration. (Prerequisite: GLG 220, GLG 122) *F. W. Beales*

GLG 322 TECTONICS

III – 2A, 2C 13 – 8, 13 – 8

Geometry of existing deformational structures in the earth's crust and reconstruction of their mechanical development. Application of rock mechanics to interpretation of geologic structures. Laboratory work emphasizes methods of structural analysis. (Prerequisite: GLG 220, corequisite: GLG 321F) *W. M. Schwerdtner*

GLG 327S GEOLOGY OF THE CANADIAN SHIELD

III – 2A 13 – 8

The stratigraphy, tectonic divisions and economic aspects of the Precambrian. Laboratory study of geological maps and reports; examination of typical rock suites in hand specimens and thin sections. (Prerequisite: GLG 321F, corequisite: GLG 322)

A. M. Goodwin

GLG 330F PHASE DIAGRAMS FOR GEOLOGISTS

III – 2A 2 – 18

Principles of phase equilibrium as applied to multicomponent silicate, sulphide and oxide systems over a wide range of temperatures and pressures of geological interest.

S. D. Scott

GLG 331S INTRODUCTION TO GEOCHEMISTRY

III – 2A; 2B (elective) 3 – – 8

Chemical aspects of geological processes, at and beneath the earth's surface. Textbook: Krauskopf. (Prerequisite: CHM 100F) *G. M. Anderson*

GLG 415F FIELD CAMP

IV – 2B ---4

A one week field camp for students in Option B, held in the Tweed, Ontario area immediately following the conclusion of the annual Third Year examinations. Instruction and experience in geological mapping. A fee, currently about $50.00 is charged to cover part of the costs of meals and accommodation. (Prerequisite: GLG 220, GLG 322)

GLG 421 MINERAL DEPOSITS

IV – 2A, 2B 23-8, 23-8

Systematic mineralogy and phase equilibria of ore minerals. Identification of ore minerals in polished section. Geochemistry of ore-forming processes. Case-history study of important ore deposits and discussion of their genesis. Synthesis of geologic techniques applied in designing exploration programs for new deposits. (Prerequisites: GLG 320, 324/330F/ MMS 309F)

GLG 425F FIELD CAMP

IV – 2A, 2C ---8

A two-week field camp for students in Option A and C held in the Tweed, Ontario area immediately following the conclusion of the annual Third Year examinations. Instruction and experience in geological mapping. A fee, currently $90, is charged to cover part of the costs of meals and accommodation. (Prerequisite: GLG 320, 322)

GLG 428F PETROLEUM GEOLOGY

IV – 2A 23-8

Application of geology to exploration for oil and gas in sedimentary basins; study of geologic conditions that govern petroleum entrapment; fluid flow through porous media; discussion of non-renewable energy resources (Fall Term of Arts and Science GLG 428) (Prerequisite: GLG 321F) *J. B. Currie*

GLG 429S GROUNDWATER GEOLOGY

IV – 2A (elective) 23-8

Geological aspects of groundwater occurrence and migration of fluids in subsurface strata. Groundwater composition and its variation in drainage basins in Canada. Exploration for and utilization of groundwater. (Spring Term of Arts and Science GLG 428) (Prerequisite: GLG 321F, GLG 428F) *J. B. Currie*

GLG 450 COMPUTER APPLICATIONS IN THE GEOLOGICAL SCIENCES

IV – 2A (elective) --48

Survey of computing and graphics hardware, programming languages, and packages of programs useful to geo-scientists and engineers; development of new programs for processing compositional or physical data of minerals and rocks, projections of multicomponent hyperspace phase diagrams, and efficient contouring, block diagram and stereo pair drawings of three-dimensional geological structures, and modelling of a dynamic non-equilibrium problem with time as one of the dimensions. *F. G. Smith*

GLG 480 EXPLORATION GEOCHEMISTRY

IV – 2A 23 – 8, 23 – 8

Geochemical and geological aspects of mineral exploration, including characterization of target, nature of detectable halos, surrounding target, typical survey methods and chemical analysis of materials obtained, statistical evaluation of data and elementary decision-making techniques. (Prerequisite: GLG 220, 324/330F)

S. E. Kesler, J. C. Van Loon

INSTITUTE FOR THE HISTORY AND PHILOSOPHY OF SCIENCE AND TECHNOLOGY

HPS 280F/S HISTORY OF SCIENCE AND TECHNOLOGY 1 – 18

An introduction to the history of science and technology to show the growth and interaction of the two fields from the earliest times to the twentieth century. Ideas originating within the two disciplines will be discussed along with their interactions and external influences.

HPS 281F HISTORY OF TECHNOLOGY AND ENGINEERING UP TO THE INDUSTRIAL REVOLUTION 1 – 18

A treatment of the origins of technology and engineering covering development in the civilizations of the Ancient World, that of Greece and Rome, the Medieval World and the period of the Renaissance. Emphasis will be placed on the developments of techniques and of machines with an indication of the content in which these occur.

HPS 282S HISTORY OF TECHNOLOGY AND ENGINEERING FROM THE INDUSTRIAL REVOLUTION TO THE PRESENT 1 – 18

A treatment of the development of machines and the utilization of new power sources during the period under discussion. The interrelation of new techniques and chemical processes with economic and other factors as well as the interaction between science and technology will be included.

HPS 283S TECHNOLOGY, ENGINEERING AND SOCIETY 1 – 18

A social history course which emphasizes the period since the Industrial Revolution. Lectures and readings concentrate on the cultural impact of technology and deal with such topics as technology and democracy, the engineering profession, and the role of government in fostering or controlling technical development.

HPS 480F/S SEMINAR ON THE EVOLUTION OF TECHNOLOGY 1–28

The purpose of the seminar is to probe, by means of historical case-studies, some facets of the context and consequences of technological change. Case-studies will be selected with reference to such themes as the relations between science, engineering and technology, technology and the extension of human capability through symbolic systems and machine making; technology and social interdependence; technology as an instrument of survival, investment, affluence; and the varied personal and public perceptions of technology. The seminar will meet weekly for discussion and case-study investigations. The course is primarily intended for Fourth Year students, but Third Year students may be accepted if places are available. The enrollment limit is 30 students. *J. M. Ham*

DEPARTMENT OF INDUSTRIAL ENGINEERING

IND 200F ELEMENTS OF INDUSTRIAL ENGINEERING I

II–4 2–28

History of Industrial Engineering. The nature and major components of modern Industrial Engineering. The scientific method – the concepts of induction and deduction. Introduction to management science with special reference to the conceptualization of systems of men and machines, decision-making, criteria of performance, and optimization. The mathematical model and its central role – the classification and utilization of models. Basic characteristics of control systems. The formulation and structuring of typical Industrial Engineering problems. *A. Porter*

IND 201S ELEMENTS OF INDUSTRIAL ENGINEERING II

II–4 2–28

A broad survey of the principles of productivity management including methods study and work simplification, plant location and facilities planning, value analysis, work measurement, production and inventory control, quality control, resources management and organization theories. *J. Vanderheyden*

IND 202F COMPUTERS AND PROGRAMMING I

II–4 2–28

Computer organization; machine and assembly language; basic data structures and their applications; fundamental algorithms, computer system architecture; computer program engineering. The course emphasizes the formulation of complete, correct, and efficient algorithms for the solution of problems drawn from engineering, computer science, information processing and operational research. Practical work includes laboratory exercises and program design assignments, involving coding in /370 Assembler and PL/1.

G. R. Comrie

IND 203S COMPUTERS AND PROGRAMMING II

II – 4 2 – 2 8

A continuation of course IND 202F with further emphasis on computer program engineering, covering the following topics: information storage and retrieval, file organization, input/output processing; data structures, list processing; introduction to functions and facilities of operating systems with specific reference to System/370; efficiency; special purpose languages. Problems chosen from engineering, operational research, and data processing, will involve coding in PL/1 and assembler. (Prerequisite: IND 202F or equivalent) *R. W. P. Anderson*

IND 301F OPERATIONAL RESEARCH I

III – 4; IV – 2B, 8 (elective) 2 – 2 8

An introduction, using simplified case studies, to the methodology, techniques and applications of operational research. Emphasis will be placed on developing an understanding of operational research as a rational approach to decision-making. Models to be presented and discussed will include ones for decision-making regarding inventory, replacement, allocation, scheduling and project management. (Prerequisites: MAT 294S, STA 282S/STA 292S, exclusion: IND 331S) *A. A. Cunningham*

IND 302S OPERATIONAL RESEARCH II

III – 4; IV – 2B, 8 (elective) 2 – 2 8

A continuation of IND 301F with emphasis on problems where more complex models are required. The focus is on the constructive interaction between problem identification and mathematical solution techniques. Models discussed include multi-period and multi-item inventory management, decision analysis, integer programming and dynamic programming. (Prerequisite: IND 301F, exclusion: IND 331S) *J. S. Rogers*

IND 303S COMPUTERS AND PROGRAMMING II

III – 4 2 – 2 8

Same as IND 203S. Offered in Session 1974–75 only. *R. W. P. Anderson*

IND 304F INDUSTRIAL RELATIONS

III – 4 (elective) 2 – 1 8

A discussion of trade unions, labour legislation and the collective bargaining process. (Prerequisite: ECO 281/ECO 100, exclusion: ECO 344) *A. Kruger*

IND 305S HUMAN FACTORS IN MAN-MACHINE SYSTEMS

III – 4 2 3 – 8

The course will be concerned with Human Factors from two points of view: (a) the anatomical, physiological and psycho-physical factors underlying the design of specific man-machine interfaces in specific environments; (b) the psychological factors involved in the determination of the allocation of function between men and machines in the overall system, specifically information processing capacity, acquisition and retention of skill, adaptability and stress. The laboratory period will illustrate and emphasize experimental methods in these areas. *P. J. Foley, J. Senders*

IND 306F APPLIED STATISTICAL ANALYSIS

III – 4 2 – 2 8

A selection of advanced topics in applied statistics including general regression theory, analysis of variance, and design of industrial and engineering experiments. Applications to cost and productivity analysis, validation of mathematical models, design of experiments in simulation, ergonomics etc. Particular attention will be paid to real situations in which the usual assumptions of statistical theory do not hold. *J. G. C. Templeton*

IND 331S OPERATIONAL RESEARCH

III – 5cs; IV – 5e (elective) 2 – 2 7

Processes of model building and solution. Problems of reliability, allocation, queueing, competition, sequencing, and co-ordination. Mathematical techniques of linear and dynamic programming, branch and bound methods, activity networks, and Markov processes. (Prerequisites: APM 281F/386S/481F; MAT 295F/290F/294S/MEC 261F; STA 287S/282S/292S/CHE 305F. Exclusions: IND 301F, 302S) *J. G. C. Templeton*

IND 412F ORGANIZATIONAL BEHAVIOUR

IV – 4 (elective) 2 – – 8

Individual and group behaviour in work organizations. Relevance to human behaviour and management problems, supervision, communications, motivation and the implementation of change.

IND 413F FUNDAMENTALS OF MANAGEMENT SCIENCE

IV – 4 (elective) 2 – 1½ 8

The course presents the basic principles of decision-making. It includes such concepts as the changing value of money, the analysis of data by Bayesian inference, the value of accurate information, the use of cardinal utility to represent aversion to risk, and the expression of individual choice by indifference curves. The concepts are illustrated with industrial applications. (Prerequisite: IND 302S) *T. A. Lambe*

IND 414S APPLICATIONS OF MANAGEMENT SCIENCE

IV – 4 (elective) 2 – 1½ 8

Algebraic procedures are presented for applying decision theory to processes where uncertainty is characterized by binominal, Poisson and normal distributions. Examples include inspection sampling, equipment replacement; marketing and project cost estimation. (Prerequisite: IND 413F) *T. A. Lambe*

IND 415F PRODUCTION SYSTEMS

IV – 4 (elective) 2 – $1^1/_2$ 8

Introduction to the basic features of production systems and methods of modelling their operation; the material flow, information and control systems. Forecasting, inventories, service level and its measurement, periodic and continuous review inventory models, ABC analysis, aggregate inventory models. The role of inventories in physical distribution. Inventories in manufacturing; requirements planning vs order point control. Planning production capacity. Production control and scheduling. Theory and simulation studies in scheduling. (Prerequisite: IND 301F) *J. A. Buzacott*

IND 416S SCHEDULING AND CONTROL

IV – 4 (elective) 2 – $1^1/_2$ 8

Methods of design for operation and control in man-machine systems. Macro-scheduling of manpower and production with discrete and continuous models. Micro-scheduling of jobs and machines. Flow and job shop scheduling. Requirements planning. Demand forecasting and parts explosion for the levels of production. (Prerequisites: IND 302S, 203S/303S) *I. B. Turksen*

IND 417F STOCHASTIC MODELS

IV – 4 (elective) 2 – $1^1/_2$ 8

A course on the analysis of stochastic models in operational research. Review of relevant aspects of probability theory; Poisson processes and renewal processes; queueing models and Markov chains; applications to problems in electronic testing, traffic flows, reliability, inventory, etc. (Prerequisites: IND 302S) *M. J. M Posner*

IND 418F SYSTEM SIMULATION

IV – 4 (elective) 2 – $1^1/_2$ 8

Computer simulation of systems. Design of continuous and discrete simulation models. Statistical foundations and methodology. Generation of random variates. Design of simulation experiments. Simultation programming languages. Applications: the analysis and design of systems for production, distribution, health care, education, and information. (Prerequisites: IND 302S, 203S/303S) *I. B. Turksen*

IND 419S INFORMATION AND OPTIMIZATION

IV – 4 (elective) 2 – $1^1/_2$ 8

Efficient transmission of information, coding of messages, capacity of an information channel, error-correcting codes; applications to practical communication systems. Unconstrained optimization in n dimensions: classical and modern algorithms; applications to non-linear programming. (Prerequisite: CSC 381F) *J. G. C. Templeton*

IND 420S MATHEMATICAL PROGRAMMING

IV – 4 (elective) 2 – $1^1/_2$ 8

Formulation of the linear programming problem, the simplex method (review), the revised simplex method, duality and the dual simplex method, postoptimality problems, parametric linear programming. Transportation problems, the fixed charge problem. Flows in network. Integer linear programming, algorithms for the all-integer and the mixed integer-continuous problem. Fractional linear programming. (Prerequisite: IND 302S) *J. Abrham*

IND 421F MANAGEMENT INFORMATION SYSTEMS

IV – 4 (elective) 2 – 1½ 8

Study of information systems in relation to both operational and decision-making activities in an organization; special attention to management planning and control activities. Models of information systems; manpower, logistics, and financial subsystems. Integrated systems. The roles of the information analyst and systems designer; the information processing organization; user implications. The development cycle of information processing systems; project control, implementation, and evaluation; equipment selection and configuration; file structures and software. Terminal-oriented systems. Case study projects. (Prerequisite: IND 203S/303S) *S. H. Cohn*

IND 423S HUMAN PERFORMANCE IN MAN-MACHINE SYSTEMS

IV – 4 (elective) 2 3 – 8

The course will cover theoretical and empirical aspects of human performance capabilities in information processing, decision making and control processes, and the loads imposed on the human operator by such tasks. The laboratory will stress the testing and validation of theories and models of human performance and work load measurement. (Prerequisite: IND 305F/S) *J. Senders*

IND 424F HUMAN INFORMATION PROCESSING IN MAN-MACHINE SYSTEMS

IV – 4 (elective) 2 3 – 8

An examination of Human Information Processing, with particular attention to the nature of biological coding mechanisms; the organization of sensory and perceptual processes; attention and vigilance; the structure and functional limitations of symbolic processes and language. (Prerequisite: IND 305F/S) *P. J. Foley*

IND 425S DYNAMICS OF GENERAL SYSTEMS

IV – 4 (elective) 2 – 1½ 8

Development of dynamic models using state space representation for planning and control of industrial, environmental, economic, and social processes. Parameter identification and control methods will be used to study the implications of growth, stability, productivity, energy transfer, and community organization on such systems along with certain topics in population dynamics and adaptive control mechanisms in changing environments. (Prerequisites: MAT 294S, MEC 357S; recommended: APM 391F) *E. E. Pickett*

IND 497F TERM THESIS

IV – 4 –6 – 8

Application of the methods and models studies in other Industrial Engineering subjects to an industrial engineering problem. The work will be carried out under the supervision of staff members. A written report is required. *Staff in Industrial Engineering*

IND 498S TERM THESIS

IV – 4 –6 – 8

Same as IND 497F.

IND 499 THESIS

IV – 4 –6 – 8, –6 – 8

Design and analysis of an engineering system to satisfy specified objectives and requirements. This project, extending over two terms, will provide the student with an opportunity to apply the knowledge and techniques of analysis acquired in his other Industrial Engineering subjects. The work will be carried out by students working in small groups, or individually, under the supervision of staff members. (May not be combined with IND 497F or IND 498S.) *Staff in Industrial Engineering*

DEPARTMENT OF MATHEMATICS

MAT 185S LINEAR ALGEBRA

I – 5 2 – 18

Matrix algebra, applications to network problems. Gauss-Jordan method for solving simultaneous linear equations. The rank of a rectangular matrix, the dimension of the vector space of solutions to a homogeneous equation, and the existence and uniqueness of solutions to simultaneous linear equations. Geometric properties of 2 × 2 determinants, definition and basic properties of n × n determinants, Cramer's Rule. Eigenvalues and eigenvectors with application to vibration problems and the simplification of quadratic forms. *J. P. Quinn, R. Luus*

MAT 186F CALCULUS I

I – 1, 2, 3, 4, 6, 7, 8 2 – 26

Limits, differentiation, maximum and minimum problems, definite and indefinite integrals, fundamental theorem, areas, volumes approximation techniques.

Staff in Mathematics and Staff in Engineering

MAT 187S CALCULUS II

I – 1, 2, 3, 4, 6, 7, 8 2 – 27

Applications of integration including moments, pressure and work, elementary functions, techniques of integration, vector differentiation, series, differential equations.

Staff in Mathematics and Staff in Engineering

MAT 188F ALGEBRA I

I – 1, 2, 3, 4, 6, 7, 8 2 – 2 6

Linearity, vectors, complex numbers, linear transformations, matrices, determinants, inverse of a matrix, scalar product. *Staff in Mathematics and Staff in Engineering*

MAT 189S ALGEBRA II

I – 1, 2, 3, 4, 6, 7, 8 2 – 2 6

Quadratic forms, orthogonal transformations, eigenvalues, eigenvectors geometry of lines and planes, linear programming. *Staff in Mathematics and Staff in Engineering*

MAT 194F CALCULUS I

I – 5 3 – 2 10

Theory and applications of differential and integral calculus, continuous functions, mean value theorem, elementary functions. *L. Rosen, P. C. Stangeby*

MAT 195S CALCULUS II

I – 5 3 – 1 7

Sequences, series, improper integrals, Taylors theorem, differential equations, functions of several variables and partial derivatives. *R. A. Smith, P. C. Hughes*

MAT 280F CALCULUS

II – 1, 2, 6 3 – 2 9

Partial differentiation, directional derivatives, tangent plane and normal line, maxima and minima, Lagrange multipliers, higher order derivatives, exact differentials. Multiple integrals, area, volume, moments, cylindrical and spherical coordinates, surface area. First and second order differential equations. Linear differential equations with constant coefficients, undetermined coefficients and variation of parameters, vibrations. (Exclusion: MAT 294S) *M. A. Akcoglu, J. Schwaighofer*

MAT 289S COMPLEX VARIABLES

II – 5 3 – 1 8

Complex plane analytic functions, Cauchy's theorem, Taylor and Laurent series, singularities, analytic continuation, contour integration, conformal mapping, and applications. *C. Davis*

MAT 290F DIFFERENTIAL EQUATIONS

II – 7 3 – 2 8

Linear ordinary differential equations and systems, series, transform and numerical solutions, nonlinear equations, introduction to partial differential equations. *N. Derzko*

MAT 293F CALCULUS

II – 3, 4, 8 2 – 2 8

Functions, of several variables, partial differentiation, maximum and minimum problems, Taylor series. (Prerequisite: MAT 186F, MAT 187S)

D. Masson, E. Marchi, J. Abrham

MAT 294S CALCULUS AND DIFFERENTIAL EQUATIONS

II – 4, 8 2 – 2 8

Multiple integrals, area, volume, moments, cylindrical and spherical coordinates, surface area, line integrals. First and second order differential equations. Linear differential equations with constant coefficients. Linear systems. Matrix methods. Vibrations.

M. A. Akcoglu, J. Abrham

MAT 295F CALCULUS III

II – 5 3 – 1 8

Convergence and uniform convergence, linear differential equations, coordinate transformations, multiple integrals, line and surface integrals, orthogonal functions.

L. T. Gardner

MAT 390S ALGEBRA

III – 5 3 – – 8

Algebra structures, semi-group, group, ring, integral domain, fields. Integers, congruences, Chinese remainder theorem, simultaneous equations, polynomial ring, Lagrange interpolation theorem. Vector spaces, dual spaces, tensor product. Lattice theory, partially ordered sets. Combinatorics, generating functions, partitions. *K. Murasurgi*

DEPARTMENT OF MECHANICAL ENGINEERING

MEC 201S DYNAMICS I

II – 3 3 – 1½ 8

Calculus of vectors. Kinematics of bodies in rectilinear and curvilinear translation, rotation, and general motion. Spacecraft orbits. Impulse, momentum and moment of linear momentum. Conservative systems. Work-energy relations. Dynamics of motion. Euler's equations. Gyroscopic mechanics. Plane motion. D'Alembert's principle. Virtual work. Introduction to generalized co-ordinates, degrees of freedom, Lagrange equations. Introduction to mechanical vibrations and balancing. *F. P. J. Rimrott*

MEC 205F DYNAMICS

II – 7 2 – 1 7

Dimensional units. Vectors. Kinematics, rectinear and angular motion, plane motion, projectiles, satellite orbits. Rigid body concept, relative motion with respect to translating and rotating co-ordinates, Euler's equations, gyroscopic effects. D'Alembert's principle. Vibration of mechanical and electrical systems, balancing. Work, energy, power, impulse, momentum. Rockets. Virtual work, Bernoulli's principle, introduction to Lagrange formulation. Reference Book: Berr and Johnston, Vector Mechanics for Engineers – Dynamics.

R. C. Flanagan

MEC 211F MECHANICS OF DEFORMABLE BODIES I

II – 3

3 ¾ 2¼ 10

Simple stress and strain; concept of stress at a point with treatment in 2-D cases (plane stress and strain); principal stresses; Mohr's method; yield and failure criterion; fatigue: application to beams, shafts, thin shells, and springs: properties of mechanical engineering materials (ferrous and non ferrous metals, polymers). *D. McCammond*

MEC 212S MECHANICS OF DEFORMABLE BODIES II

II – 3

3 ¼ 1¼ 8

Experimental stress analysis methods (photoelasticity, strain gauging, brittle lacquer); generalized equilibrium and compatibility relationships with application to thick cylindrical pressure vessels and rotating discs; theory of thin plates; energy methods of solution; design methods with plastics; elementary plasticity. *D. McCammond*

MEC 261F DIFFERENTIAL EQUATIONS

II – 3

3 – 3 10

First-order equations. Second-order equations. Operator techniques. Systems of equations. Power series for variable-coefficient equations. Numerical techniques.

A. W. Neumann

MEC 262S METROLOGY

II – 3

3 – 2 8

Nature of experimental error, its minimization and reponse characteristics of physical systems. Emphasis is on probability, statistical analysis of experimental data, principles of quality control and design of experiments. Topics to be covered include evaluation of random processes and computer techniques for statistical treatment of continuous data; case studies and discussion of selected mechanical measurements. *Staff*

MEC 302S DYNAMICS II

III – 3, IV – 3 (elective)

3 – 1½ 10

Brief review of basic laws of classical Newtonian mechanics. Euler angles and gyrodynamics. Generalized co-ordinates and their transformation. Theorem of virtual work and d'Alembert's principle. Kinetic and potential energy. Dissipative power functions and Lagrange equations of motion. Determination of constraint forces. Variational dynamics. Hamilton's equations and principle. Astronautics. Orbital mechanics. Rocket mechanics.

R. C. Flanagan

MEC 303S VIBRATIONS

III – 3 3 1 2 10

Systems modelling and analysis. Analysis of single degree of freedom systems. Various types of damping forces. Vibration isolation. Vibration measuring instruments. Steady state and transient vibrations. Vibration of multi-degree of freedom systems. Analog and digital computer solution methods. Numerical methods of frequency analysis. Lagrange equations and Hamilton's principle. Energy methods. Vibration of strings, beams and plates. *D. L. Allen*

MEC 313S ELASTICITY

III – 3, IV – 3 (elective) 3 – 1½ 10

Review of stress and strain tensors and generalization of Hooke's law. Equations of equilibrium and compatibility. Solution procedure using displacements and stress functions. Illustration of the theory by application to beams, rotating discs, thick composite cylinders, torsion of non-circular sections, stress concentration and thermal stresses. Introduction to finite difference and finite element methods of solution. *B. Tabarrok*

MEC 315S STRESS ANALYSIS

III – 5nt; 5p (elective) 3 – 1 8

Stress and strain at a point (tensor notation), equilibrium and compatibility relationships, stress functions, energy methods, finite element and finite difference techniques, thermal stress analysis, creep of metals, experimental stress analysis. *D. McCammond*

MEC 321F THERMODYNAMICS

III –3; II – 4, III – 4 (elective) 3 1 2 10

Review of energy and matter concepts; first law of thermodynamics illustrated by closed and open system applications; the state postulate; characteristics of pure substances; the ideal gas; entropy and the second law of thermodynamics; fluxes and production of entropy; application of second law to engineering systems; processes and ideal cycles; flow and non-flow availability analysis; mixtures of non-reacting substances; thermodynamic potentials and equilibrium. *D. S. Scott*

MEC 322S THERMAL ENERGY CONVERSION

III – 3 3 3 – 10

The application of thermodynamics to the analysis and design of heat engines, refrigerators and processes associated with useful energy transformations; engine and turbine cycles for vapours and gases; combustion processes; psychrometry and air conditioning; consequences of thermodynamic potential and availability considerations in direct energy conversion devices. *F. C. Hooper*

MEC 323S COMBUSTION THEORY

III – 3, IV – 3 (elective) 3 – 1½ 1

Fundamentals of combustion. Physical and thermo-chemical relationships of combus tion. Mechanisms of burning. Ignition. Stabilization of flames. Limits of flammability. Laminar and turbulent flames. Diffusion flames. Practical combustion systems for gaseous, liquid and solid fuels. *A. B. Allen*

MEC 327F HEAT ENGINEERING

III – 5nt; II – 4, III – 4 (elective) 2 3 – 8

This course consists of a study of the fundamental concepts of macroscopic thermodynamics, and their applications to closed and open dynamic systems. An examination of the principal power cycles is undertaken in relation to the properties of the working media involved. Emphasis is placed on a thorough understanding of the three basic laws of thermodynamics. Textbook: *Concepts of Thermodynamics* – Obert. Reference Books: Hall and Ibele, *Engineering Thermodynamics;* Van Wylen, *Thermodynamics*.

F. C. Hooper

MEC 341F FLUID MECHANICS I

III – 3; II – 4, III – 4 (elective) 3 2 1 10

Introductory concepts. Fluid properties. Systems of stresses. Hydrostatics. Kinematics and dynamics of flow. Viscous laminar flow. Boundary layer theory. Turbulent flow. Internal and exterior flows. *J. F. Keffer*

MEC 342S FLUID MECHANICS II

II – 3, IV – 3 (elective) 3 – 1½ 10

Kinematics of fluid motion: equation of continuity, stream functions, circulation and vorticity. Dynamics of ideal fluid flow: fundamental equations, fluids at rest, filament flow, potential flow. Dynamics of real fluid flow: fundamental equations, similitude, exact solutions, creeping flow, boundary layers. Turbulent flow: general features, wall turbulence, free turbulence. Diffusion processes: molecular diffusion, diffusion and convection in turbulent flow, dispersion in one-dimensional flow. Tutorials, films and selected experiments complementing lecture material. *H. J. Leutheusser*

MEC 349S TRANSPORT PHENOMENA

III – 8; III – 4 (elective) 3 1½ 1½ 8

A study of the forces and motion produced by various fluid properties. Gravitational, viscous and inertial forces are considered in detail. Momentum, energy and continuity relation, boundary-layer approximation, turbulence, flow in pipes and around submerged bodies. Steady-state conduction in one dimension; extended surfaces; heat conduction with two or more independent variables; forced convection and dimensional analysis; heat transfer by free convection; radiant heat transfer; heat transfer by combined conduction and convection; heat transfer in liquid metals. *J. F. Keffer*

MEC 351F FLUID MECHANICS

III – 1, 2C; II – 4, III – 4 (elective) 3 3 – 10

Introduction: fluid and flow characteristics dimensions and units. Fluid statics: funda-

mental equation, gravity and inertia action, engineering applications. Fundamentals of one-dimensional flow: conservation principles of mass, energy and momentum, applications to ideal-fluid flow. Dimensional analysis and similitude. Fundamental concepts of real fluid flow: laminar and turbulent flow, boundary layer concept, flow about immersed objects. Flow in closed conduits: flow development, friction loss, minor loss, typical pipe-flow problems. Flow in open channels: uniform flow, varied flow. Special topics of interest to civil engineers. Tutorials, films and experiments complementing lecture material.
H. J. Leutheusser

MEC 354F FLUID MECHANICS

III – 5nt 3 3 – 8

A fundamental approach to the mechanics of fluid motion. Continuum concepts. Kinematics and dynamics of flow. Irrotational motion. Vorticity. Laminar flow solutions. Turbulent motions. Applications to conduit flow. Free surface waves. Fluid machinery.
J. F. Keffer

MEC 357S CONTROL ENGINEERING

III – 4 2 1 1 8

Introduction to the dynamic behaviour of linear systems. The feedback principles. Stability and response of linear control system. The convolution theory. Transfer functions of linear systems. Analysis and design of linear control system introduction to servomechanism technology for control system design. Problems and laboratory experiments will accompany the lectures. (Prerequisite: MAT 294S). *D. B. Cherchas*

MEC 362F ENGINEERING ANALYSIS I

III – 3 3 – 3 10

Analytical techniques include Laplace transforms, series solutions of ordinary differential equations, special functions, vector calculus. *D. F. James*

MEC 363S ENGINEERING ANALYSIS II

III – 3 3 – 3 10

Continuation of Engineering Analysis I. Topics include boundary value problems and eigenfunction expansions, higher-dimensional calculus, introduction to partial differential equations, functions of a complex variable. *C. A. Ward*

MEC 371F ANALYSIS AND DESIGN OF MECHANISMS

III – 3 3 – 3 10

Types of mechanisms; analysis and design to meet functional requirements of positioning, force application and energy transmission. Synthesis and analysis of linkages, cams, and gears. Hydraulic actuators. Design for dynamic loading and energy storage. Springs and flywheels. Load capacity of bearings and gears. Stress concentration factors.
I. W. Smith

MEC 420F THERMAL ENVIRONMENTAL DESIGN

IV – 3 (elective) 3 1½ – 10

Psychrometrics, heating and cooling. Refrigeration including vapor compression, absorption and thermolectric devices. Solar radiation. Design and applications to the control of environmental systems in residential, public and industrial buildings and processes. Computer-aided design procedures. *A. H. Abdelmessih*

MEC 424F THERMAL POWER GENERATION

IV – 3 (elective) 3 1½ – 10

Application of thermodynamic cycles to the generation of power. Conventional energy sources, utilization and rate of depletion, alternate sources. Design and operating characteristics of internal combustion machines, gasoline and diesel engines, gas turbines. Overall design considerations in steam power generation systems, heat balances, etc. The external combustion engine. Sources of air pollution within the power generation field, problems of control and possible solutions. *A. B. Allan*

MEC 425S MICROSCOPIC THERMODYNAMICS

III – 3, IV – 3 (elective) 3 1½ – 10

Review of Thermodynamics. The fundamental relation of thermodynamics. Legendre transformation of the fundamental equation. Thermodynamic potentials and the condition for equilibrium. The molecular approach to the description of thermodynamic systems. Ergodic hypothesis, ensemble averages, temperature, and entropy. Fluctuations about the equilibrium states and rate processes. *C. A. Ward*

MEC 426F STATISTICAL THERMODYNAMICS

III – 5nt 3 1½ – 10

The idea of ensemble averages is used to develop the expression for the fundamental relations of thermodynamics in terms of molecular properties; partition functions for the ideal monatomic crystal, the ideal monatomic gas and black body radiation are developed. A molecular interpretation of entropy is developed and fluctuations about an equilibrium state are discussed along the ergodic hypothesis and rate processes.

C. A. Ward

MEC 428F ENERGY CONVERSION

IV – 5nt 3 3 – 11

The theory of fluctuations and the Onsager principle are discussed. Irreversible thermodynamics is developed and used to analyse direct energy conversion devices. Thermoelectric processes such as the Seebeck, Peltier, and Thomson effect are considered and systems such as fuel cells, thermoelectric, thermionic, and magnetohydrodynamic generators are analysed. *C. A. Ward*

MEC 431F/S HEAT AND MASS TRANSFER

IV – 3

3 1½ 1½ 9

Steady state and transient conduction, surface and gas radiation, convection, boiling, condensation and combined mechanisms of energy transport are considered, together with an introduction to mass transport. Application of these topics in the design of heat transfer equipment. *F. C. Hooper, A. H. Abdelmessih*

MEC 433S HEAT TRANSFER

IV – 5nt

2 – 1 8

Steady state and transient conduction, surface and gas radiation, convection, boiling, condensation and combined mechanisms. Special attention is given to analogue and computational procedures and to consideration of the manner in which novel or complex problems may be approached. *A. H. Abdelmessih*

MEC 443S APPLIED FLUID MECHANICS

IV – 3

3 3 – 9

Study of one-dimensional gas dynamics encountered in Engineering practice including nozzle flows, friction, heating and normal shock waves. Water hammer and design procedures for alleviation, hydraulic transients in pipe system. Design principles and operational characteristics of flow machines, primarily turbo-machines. Lift and drag on submerged bodies and application to flow-induced vibrations. Dispersion of air pollution and concepts of pollution control. *W. D. Baines*

MEC 452S HYDRAULIC ENGINEERING

IV – 1, 2C (elective)

3 2 – 8

Review of flow principles. Techniques of field measurement. Open channel and closed circuit flow. Hydraulic structures and appurtenances, transitions, controls; dams; navigation works; methods of construction. Hydraulic machinery, pumps, turbines, power and control systems. Design and testing of hydraulic engineering systems; analytical procedures, numerical methods and computer simulation. Systems analysis. *G. D. Ransford*

MEC 455F/S CONTROL SYSTEMS I

IV – 3

3 1½ 1½ 10

Analysis and synthesis of linear feedback systems by frequency response methods and the rootlocus technique. Introductions to nonlinear control systems, the statespace technique, and digital computer control. *J. Vande Vegte*

MEC 456S CONTROL SYSTEMS II

IV – 3 (elective)

3 – 1½ 10

The analysis of physical systems by state-space techniques. Controllability and observability of multivariable feedback systems. Design of multivariable feedback systems by the techniques of optimal control and of pole assignment. Introduction to Fluid Power Control and Fluidics. (Prerequisite: MEC 455F) *J. Vande Vegte*

MEC 472S DESIGN

IV – 3 2 – 6 10

This course is intended to utilize all of the students' knowledge and training in Mechanical Engineering and to apply this knowledge to design. The lectures will cover design practice, criteria and methodology. The projects will be broad in nature and will be supervised by staff members who will pose projects on which students will work in small groups. *Staff*

MEC 473F COMPUTER-AIDED DESIGN

IV – 3 (elective) 3 – 1½ 10

Value theory, decision theory. Modelling numerical methods, problem oriented computer languages. Analytical optimization methods. Numerical optimization: linear, boundary and multi-dimensional search techniques; linear and dynamic programming. Reliability. Design simulation techniques. Computer graphics. *R. G. Fenton*

MEC 475S MANUFACTURING ANALYSIS

III – 3, IV – 3 (elective) 3 – 1½ 10

Introduction to plasticity. Mechanics of metal forming and machine processes. Tool wear. Machine tool vibration. Surface finish. Thermal effects in machining and forming. Economy of machining. Modern machining processes. Numerical and adaptive control of machines. *R. G. Fenton*

MEC 499 THESIS OR DESIGN PROJECT IV

IV – 3 – – – 11, – – – 3

The thesis may consist of one of the following:

1. Group design projects:
   Large projects covering a broad range of mechanical engineering will be offered. The projects will refer to realistic situations and contribute to the solution of the design problem, i.e. individuals will specialize in the various aspects of the design.
2. Individual research and design projects:
   With the approval of the thesis coordinator and a supervising professor a student may perform original research, experimentation, or specialized design.
3. Interdisciplinary group design:
   The interdisciplinary group design course APS 401 may be taken in lieu of MEC 499.
   Full details of the thesis-project requirements are available on request from the Departmental Office. *Staff*

DEPARTMENT OF METALLURGY AND MATERIALS SCIENCE

MMS 100S STRUCTURE AND PROPERTIES OF MATTER

I – 1, 2, 3, 4, 5, 6, 7, 8, (elective) 3 1½ – 8

An introduction to the structure and properties of the different states of matter in terms of the interatomic potential and thermal energy. A comparison of solids, liquids and gases, with special attention being directed towards crystalline solids, in order to establish a theoretical framework to account for the properties of engineering materials. Specific topics considered include elasticity, viscosity, surface properties and capillarity, wave motion and the thermal and optical properties of matter.

Staff in Metallurgy and Materials Science and Physics

MMS 201F STRUCTURE OF MATERIALS AND METALLOGRAPHY

II – 8 2318

A course dealing with both the theoretical interpretation and the experimental determination of the structure of solids. Structure is discussed at various levels, viz. macrostructure, single phase microstructures, phase equilibria and binary phase diagrams, equilibrium and non-equilibrium two phase microstructures and crystal structure. Metallographic techniques for the determination of microstructure by optical, x-ray and electron microscopy are considered, as are quantitative metallography and the introductory principles of x-ray diffraction.

W. A. Miller

MMS 202F METALLURGICAL THERMODYNAMICS I

II – 8 2 – 38

The physical – chemical properties of matter. Ideal and real gases, liquids, solids. Heat capacity theory and Debye's law. Calculations of enthalpy, entropy and of free energy for pure materials. First and second order transitions. Chemical equilibria. Heterogeneous reactions – Ellingham diagrams. Activities and other partial molar properties. Experimental techniques for thermodynamic measurements. (Prerequisite: MAT 186F).

S. N. Flengas

MMS 203S METALLURGICAL THERMODYNAMICS II

II – 8 2 – 38

Chemical equilibria at high temperatures in extractive metallurgy. Slag-metal reactions – Order-disorder phenomena – Theory of solutions. Partial molar properties and Thermodynamic relationships in phase diagrams – Ternary solutions – Analytical and graphical solutions of the Gibbs-Duhem relationships. Standard States for the evaluation of partial molar properties and conversions. Solubility of gases in liquids. Phase diagram relationships in Metallurgical Systems. Binary and Ternary Systems.

S. N. Flengas, J. M. Toguri

MMS 204S MATERIALS CHEMISTRY

II – 8 2329

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber cycle for ionic compounds and replacement reactions. Point defects, non-stoichiometry and conductivity. The Schroedinger equation and its solution in terms of orbitals. Bonding and physical properties of metals and alloys, and covalently – bonded solids. Inorganic and organic polymers. The laboratory deals with the instrumental analysis of ores, concentrates, slags and alloys. *C. B. Alcock, R. T. McAndrew*

MMS 205S MATERIALS SCIENCE

II – 8 2 – 2 7

A course on the structure and properties of plastics, glass and ceramics. The course discusses the relationship between the microstructure and physical and mechanical properties of non-metallic materials. *G. C. Weatherly*

MMS 221F MATERIALS SCIENCE I

II – 7; II – 4, III – 4 (elective) 3 1½ – 8

Part I deals with the structure of materials in terms of atomic bonding, crystal structure, defect structure and microstructure. Various processes that influence structure and properties of materials are discussed, such as diffusion, phase transformations, plastic deformation, fracture and the decomposition of super-saturated solid solutions. Other topics covered include the purification of semiconductor materials and the growth of single crystals, a discussion of selected useful metallic and ceramic materials, and a brief outline of their fabrication techniques. Part II deals with the macroscopic response of materials to mechanical loading with special reference to deformability, stability and strength of structural elements which are subjected to axial and biaxial stresses, flexure and torsion. Recommended Textbook: Ruoff, Introduction to Materials Science. (Exclusions: MMS 222F, 223S, 250S) *J. W. Rutter, R. H. Mills*

MMS 222F MATERIALS SCIENCE

II – 4, III – 4 (elective) 3 3 – 8

The effect of atomic bonding, crystal structure and microstructure on the electrical, magnetic, chemical, and mechanical properties of engineering materials. Typical examples from the following groups of materials will be studied in a case-study approach to materials science: metals, ionic compounds, semiconductors, polymers, inorganic compounds, and biomaterials. The laboratory experiments will illustrate the characterization of materials and the relation between the structure and properties of materials. (Exclusions: MMS 221F, 223S, 250S) *B. Ramaswami*

MMS 223S MATERIALS SCIENCF

II – 3; II – 4, III – 4 (elective) 3 1½ – 8

The effect of microscopic and atomic structures on the properties of engineering materials. The topics covered include atomic bonding and structures of materials, diffusion, crystal growth and solidification, plastic deformation and annealing, precipitation hardening, phase transformations especially in ferrous materials, relationships between structures and mechanical properties of metallic and non-metallic materials, and composite materials. The laboratory experiments are designed to illustrate the principles underlying the relationship between structures and properties of engineering materials. (Exclusions: MMS 221F, 222F, 250S) *K. T. Aust*

MMS 224F INTRODUCTION TO MINERAL ENGINEERING

II – 2 2 – 17

A broad survey of mineral engineering and its relation to geology and industry. The course deals with the preparation and processing of materials extracted from the earth such as sand, gravel, limestone and metallic ores. Operations treated include crushing and grinding, particle sizing and classification, liquid-solid separations, mineral concentration, hydrometallurgical (leaching, precipitation) and pyrometallurgical (roasting, sintering, smelting) operations. The course is illustrated through flowsheets of typical processes. Relevant aspects of mineralogy and slag-metal reactions are included. The course is intended to show the importance and relation of basic scientific and engineering principles to mineral technology and to provide a general familiarity with the subject to insure that subsequent specialized instruction is appreciated in its proper context.

H. U. Ross

MMS 226S MATERIALS CHEMISTRY

II – 2; II – 4, III – 4 (elective) 2 – 28

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber cycle for ionic compounds and replacement reactions. Point defects, non-stoichiometry and conductivity. The Schroedinger equation and its solution in terms of orbitals. Bonding and physical properties of metals and alloys, covalently-bonded solids. Inorganic and organic polymers. *C. B. Alcock*

MMS 227S MATERIALS SCIENCE II

II – 7; II – 4, III – 4 (elective) 2 1½ – 7

The magnetic, dielectric and conductive properties of materials, as related to their structure. Magnetic properties: dia-, para-, ferro-, antiferro-, and ferri-magnetic phenomena; magnetic domains and domain wall motion; "hard" and "soft" magnetic materials, magneto-striction. Dielectric materials; insulating properties, conduction mechanism, dielectric loss. Ferro-electric materials. Electrical conduction; temperature dependence effect of composition and structure on conductivity. Thermoelectric phenomena. Textbook: Rose et. al., *The Structure and Prop. of Materials,* Vol. IV. (Prerequisite: MMS 221F, 222F, 223S, or 250S) *U. M. Franklin*

MMS 250S MATERIALS SCIENCE

II – 5 (elective) 2 1½ – 8

The effect of atomic structure, crystal structure, and microstructure on the physical, chemical and mechanical properties of solid materials. Representative examples of metals, ionic crystals, semiconductors, polymers, and inorganic compounds will be used in a case-study method to illustrate the principles of materials science. The laboratory experiments complement the lectures and demonstrate the methods and techniques of materials science. (Exclusions: MMS 221F, 222F, 223S) *B. Ramaswami*

MMS 301F MINERAL PROCESSING I

III – 8, 2B 2318

The theory and practice of mineral benefication including particle size measurement, comminution, sizing, liquid-solid separation and ore concentration. The course also includes the relevant aspects of mineralogy, surface chemistry and the movement of solid particles in liquid media. *H. U. Ross*

MMS 302F ELECTROCHEMICAL AND KINETIC PROCESSES

III – 8; IV – 2B (elective) 2 – 48

Electrochemistry of solids, liquids and of high temperature systems – e.m.f. series – Fused salt electrochemical cells – Thermodynamics of imperfections and properties of ionic solids. Non-stoichiometric oxides, sulfides and carbides. Non-ionic conductivity mechanisms in solids. Fuel cells. Corrosion reactions in aqueous solutions and fused salts. Irreversible electrode reactions – Overvoltage. Kinetics of Heterogeneous reactions. Diffusion controlled processes. Fick's law of diffusion. Application of theory to metallurgical operations. *S. N. Flengas, J. M. Toguri*

MMS 303F PHYSICAL METALLURGY

III – 5m, 8 33 – 8

An introduction to the fundamental basis of microstructure control stressing the importance of alloying, plastic deformation and annealing. The principles of solidification, crystal growth, and phase transformations in solids are considered in detail. (Prerequisite: MMS 201F, co-requisite: MMS 331F for those without MMS 201F)

U.M. Franklin, G. B. Craig, J. W. Rutter

MMS 304S PHYSICS OF METALS

III – 5m, 8 33 – 8

Plastic deformation and mechanical properties are discussed in terms of dislocation theory. The annealing processes of recovery, recrystallization and grain growth and the structure and properties of interfaces in materials are also considered. (Prerequisite: MMS 303F) *K. T. Aust, W. A. Miller, B. Ramaswami*

MMS 305S EXTRACTIVE METALLURGY I

III – 8 43 – 9

The extraction and refining of metals by hydrometallurgical techniques in terms of thermodynamic and kinetic principles. A fundamental treatment of the pyrometallurgical processes involved in the production of the important metals, including oxidation of sulphides in the liquid and solid states, reduction of oxides and chlorides, matte-slag and metal-slag equilibria and kinetics, the distillation of metals. Experiments in materials processing, including roasting, smelting, leaching, refining, electrolysis. (Prerequisite: MMS 302F) *Staff in Metallurgy and Materials Science*

MMS 306F METALLURGICAL THERMODYNAMICS

III – 5m 3 – 49

A study of chemical equilibria at high temperatures in metallurgy; slag-metal reactions; chemical theory of solutions; alloys; phase transformations; thermodynamic relationships in phase diagrams; statistical concept of entropy; simple partition functions; quasichemical approach to the theory of solutions; methods of investigating thermodynamic properties. *S. N. Flengas, A. McLean*

MMS 307S MATERIALS SCIENCE

III – 5m 3 – – 8

The course deals with the relationship between the structure and properties of non-metallic solids. Topics to be discussed are: thermodynamics and kinetics of phase transitions, phase diagrams, diffusion, crystal defects, and the effect of structure on physical, chemical and mechanical properties. (Prerequisite: MMS 303F)

G. C. Weatherly

MMS 308F CERAMIC MATERIALS

III – 8 (elective) 2 – 28

The practical application of ceramics in high temperature corrosive environments. Topics to be discussed include transport phenomena in ceramics, corrosion resistance, thermal shock resistance and mechanical strength. Ceramic coatings. Refractories.

C. B. Alcock, G. C. Weatherly

MMS 309F MINERALS EQUILIBRIA

III – 2B 3 – 28

The methods and formulations of thermodynamics will be discussed on the basis of the three laws of thermodynamics. Phase equilibria diagrams will be presented for one, two and three component systems and equilibria criteria will be examined for simple mineral systems. *A. McLean, J. M. Toguri*

MMS 310S EXTRACTIVE METALLURGY

III – 2B 43 – 9

Course MMS 305S with alternative laboratory assignments given with Course MMS 204S. *Staff in Metallurgy and Materials Science*

MMS 331F MATERIALS SCIENCE LABORATORY

III – 8 (elective) – 317

Projects in materials science, chosen by the student, and carried out in close consultation with a staff supervisor. (Corequisite: MMS 303F)

Staff in Metallurgy and Materials Science

MMS 332S EXTRACTIVE METALLURGY LABORATORY

III – 8 (elective) –3 1 7

A laboratory project in extractive metallurgy relating to Courses 301 and 305. (Prerequisite: MMS 301F, corequisite: MMS 305S) *Staff in Metallurgy and Materials Science*

MMS 333F STRUCTURE OF MATERIALS

III – 5m –2 2 8

The structure of solids is treated in tutorial sessions and laboratory projects. Subjects covered include crystallography, phase equilibria, binary phase diagrams and microstructive of materials. *W. A. Miller*

MMS 401F EXTRACTIVE METALLURGY II

IV – 8 3 3 1 9

Oxidation reactions, acid and basic steelmaking; transport considerations with reference to open hearth, converter, B.O.F. and electric furnace steelmaking; continuous steelmaking processes, the influence of vacuum treatment and argon rinsing in steelmaking. The refining of metals in terms of thermodynamic and kinetic principles. (Prerequisite: MMS 305S) *A. McLean, H. U. Ross, J. M. Toguri*

MMS 402F SOLID STATE SCIENCE

IV – 5m, 8 3 3 1 9

The course deals with relationships between crystal structure and the electronic and magnetic properties of solids, as well as the formation and stability of alloy phases and intermetallic compounds. The laboratory will be devoted mainly to x-ray and electron techniques applicable to both single crystals and polycrystalline materials. (Prerequisite: MMS 304S) *U. M. Franklin, G. C. Weatherly*

MMS 406S ADVANCED CHEMICAL METALLURGY

IV – 8 (elective) 1 – 3 7

Selected topics related to the behaviour of metallic, ceramic, glass and metal-slag systems at high temperatures. Thermodynamic and transport properties of alloys and metallic oxides, carbides, silicides, etc. High temperature corrosion reactions and vaporization processes. (Prerequisites: MMS 302F, MMS 401F) *A. McLean, J. M. Toguri*

MMS 407S METALLURGICAL SYSTEMS ANALYSIS

IV – 8, 2B (elective) 2 – 1 7

Through regular seminars, visiting industrialists share aspects of their practical experience with the students to help draw together the many factors involved in process evaluation and operational-decision making. The seminars include case studies of diverse activities in research and development, plant operations, marketing, finance, politics and other areas. *R. T. McAndrew, A. McLean*

MMS 408S MATERIALS ENGINEERING

IV – 8 (elective) 3 – – 7

A course on the processing and selection of engineering materials. Processing techniques such as casting, metal working, welding, heat treatment, sintering and vapour deposition are considered. Factors governing materials selection are discussed in general and in relation to such specific applications as high and low temperature service, corrosion-resistant materials, nuclear materials, electronic materials, etc. (Prerequisite: any materials science course) *Staff in Metallurgy and Materials Science*

MMS 409S HIGH TEMPERATURE PHYSICAL CHEMISTRY

IV – 5m; IV – 8 (elective) 2 – 2 8

Properties of solids and liquids at high temperatures; thermodynamics of defects; solid oxide electrolytes; mechanism of electrical conductivity in ceramic phases; fused-salt electrolytes; reactions in fused-salt media; electrochemical cells at high temperatures; fuel cells; structural properties of simple and complex liquid phases; electrochemical corrosion and passivation; quasichemical theory of solution properties; elements of statistical thermodynamics; experimental methods at high temperatures. *S. N. Flengas*

MMS 410F THEORY OF METALLURGICAL REACTIONS

IV – 5m 2 – 2 8

Metal extraction and refining processes are examined in terms of chemical thermodynamics and kinetics. The principles and methods of extraction of ferrous and nonferrous metals, roasting, leaching and electro-winning are typical of the subjects discussed. (Prerequisite: MMS 306F) *J. M. Toguri*

MMS 411S ADVANCED MATERIALS SCIENCE

IV – 5m; 8 (elective) 3 3 – 8

This course is offered to those students whose primary interest lies in the research aspects of materials. Recent developments in materials science are discussed in fields such as crystal growth, purification of materials, high-vacuum studies, preparation and characterization of clean surfaces, interfacial structures and properties, Auger emission and impurity segregation, environmental interactions. The laboratory work consists of research projects on contemporary problems in the field of materials science. (Prerequisite: MMS 402F) *K. T. Aust, J. W. Rutter*

MMS 412S MINERAL PROCESSING II

III – 2B; IV – 8 (elective) 2 1½ – 7

This is a continuation of course 301F. Topics considered include particle size analysis and characterization; the motion of solids in fluids under laminar, transitional and turbulent conditions and the application of surface chemistry to minerals and flotation. (Prerequisite: MMS 301F) *H. U. Ross*

MMS 413F HYDROMETALLURGY

IV – 2B; IV – 8 (elective) 2 1½ 18

Theory and practice of metal production from ores and concentrates by chemical reaction in aqueous solution. Thermodynamic and kinetic fundamentals are emphasized. Topics covered include leaching, solution purification, metal precipitation, electrowinning and electrolytic refining. Examples of integrated process flowsheets are studied and compared to alternative pyrometallurgical processes. *R. T. McAndrew*

MMS 414F MINERAL ENGINEERING

IV – 2B 2 3 19

This course deals with the design, operation and control of mineral processes. Operations studies include comminution, concentration, dewatering, roasting, agglomeration, balling, sintering, sampling, materials handling and process instrumentation. The laboratory will consist of a design project plus a one-week pilot-plant project in conjunction with the Ontario Research Foundation at a time to be arranged. *R. T. McAndrew, H. U. Ross*

MMS 415S PHYSICS AND CHEMISTRY OF SURFACES

IV – 2B 2 – 18

Structure of inorganic surfaces, surface area measurement and the determination of surface free energies. Adsorption isotherms and the kinetics of surface reactions. Surface migration and desorption from surfaces. The structure of surface layers and of bonding between solids. *Staff in Metallurgy and Materials Science*

MMS 416S NUCLEAR MATERIALS

IV – 8 (elective) 3 – 17

An introduction to structure-property relationships in nuclear materials such as uranium, thorium, zirconium, stainless steel, etc. Topics to be discussed include properties of liquid metals and corrosion in liquid environments; creep, thermal cycling and thermal fatigue; radiation damage; nonstoichiometry in inorganic compounds; production and fabrication techniques of fuel rods and canning and cladding materials. Production and fabrication of uranium, thorium, zirconium and other reactor materials. (Prerequisite: any Materials Science course) *C. B. Alcock, B. Ramaswami*

MMS 417F MINERAL ENGINEERING

IV – 8 (elective) 2 1½ 18

Same as MMS 414F but without pilot-plant project which is included in MMS 401F. *R. T. McAndrew, H. U. Ross*

MMS 431F POWDER METALLURGY

IV – 8 (elective) 2 – 18

Production and agglomeration of powders, the theory and practice of sintering, and the application of powder methods to the production of refractory metals, cemented carbides and other materials. (Prerequisite: any Materials Science course)

K. T. Aust, J. W. Rutter

MMS 499 THESIS

IV – 8 –6 – 6, – 12 – 12

The student chooses an experimental problem involving original work, which normally is related closely to the current research of a staff member. The student is asked to prepare a written report and two oral presentations describing the work. No laboratory time is specified for the Engineering Science (Materials Science option) thesis (APS 495) but the project is of essentially the same extent as that described above.

Staff in Metallurgy and Materials Science

DEPARTMENT OF PHILOSOPHY

PHL 291F SCIENCE AND SOCIETY 2 – – 8

A philosophical examination of the role of the scientist, technologist, and engineer in contemporary society, including some of the following problems: pollution, and its control, war research, the "think tank", technocracy, nationalism.

PHL 292S SCIENCE AND PHILOSOPHY 2 – – 8

The advance of the physical, social, and life sciences has produced successive changes in concepts familiar to the ordinary man (space and time; cause and effect; man and animal; purpose, motive, freedom). The philosopher has attempted to work out the implications of these changes. This course will examine some of these attempts.

DEPARTMENT OF PHYSICS

PHY 180F ELEMENTS OF PHYSICS I (MECHANICS)

I – 5 2 1½ 1 9

Introduction to atomic and nuclear physics. Addition and multiplication of vectors with physical applications. Trajectories of particles. Rotational motion, conservation of angular momentum, moments of inertia, gyroscopes. Non-uniform accelerations, simple harmonic motion. Reaction kinematics. Philosophy of conservation laws and symmetries. Gravitational and other natural forces. *R. K. Logan*

PHY 181S ELEMENTS OF PHYSICS II (THERMODYNAMICS AND STATISTICAL PHYSICS)

I – 5 3 1½ 1 9

Heat and thermodynamics, the laws of thermodynamics with physical applications. Ideal gases, kinetic theory, Maxwell-Boltzmann distribution of molecular velocities, specific heats of monatomic and polyatomic gases. Basic probability notions, postulates of statistical physics, entropy, absolute temperature, the canonical distribution. Crystalline symmetry, elastic behaviour of solids. Dynamics of crystalline lattices, specific heats of solids, heat conductivity, thermal expansion.

PHY 215F GEOPHYSICS

II – 4, 6 (elective) 2 – 18

A course in the physics of the earth, atmosphere and magnetosphere, offered to students in science. The principal conclusions reached by geophysicists about the planet, its evolution, and the processes taking place on it are introduced, as well as an outline of the methods utilized in attacking current research problems. Reference: Flohn, *Weather and Climate*; Gass, Smith and Wilson, *Understanding the Earth*. *R. List, G. Garland*

PHY 218 APPLICATIONS OF PHYSICS IN MEDICINE

II – 4 (elective) 2 – 18, 2 – 18

This course covers particular parts of physics which are often applied in medical practice and research and intimately mixes the pure with the applied physics. Topics include: radioactivity and tracer techniques, neutron activation analysis, optics and the resolution of instruments, x-rays and holography, electricity and instruments used in medicine, mechanics of the body, hydrodynamics of the circulating system. *K. G. McNeill*

PHY 244S ELASTICITY AND FLUID MECHANICS

III – 5g (elective) 2 – – 8

A mathematical course in classical physics particularly for those interested in geophysics and meteorology. The elasticity part includes the definition and use of cartesian tensors to describe infinitesimal strains, stresses, and their relations. Fluid mechanics include fluid statics, continuity, Bernoulli, Euler, and Navier-Stokes equations, potential flow, vortex flow. Textbook: R. R. Long, *Mechanics of Solids and Fluids;* D. R. F. Harleman, *Fluid Dynamics*. *G. M. Graham*

PHY 280F ELEMENTS OF PHYSICS III (FIELDS AND WAVES)

II – 5 3 1½ 18

Principle of relativity, Lorentz transformation, Einstein's special relativity, relativistic dynamics, space-time geometry, the electromagnetic field, analysis of a vector field. Matter in electrostatic and magnetostatic fields, electromagnetic field of uniformly moving charges, Maxwell's equations, radiation and its detection. Interference of electromagnetic waves, Huygen's principle and diffraction. Maxwell's equations in the presence of matter.

PHY 281S ELEMENTS OF PHYSICS IV (QUANTUM PHYSICS)

II – 5 2 1½ 18

Classical systems and quantum systems. Wave-particle duality, Heisenberg uncertainty principle, electron and nuclear spin. Schroedinger equation. Eigenvalues and eigenfunctions. Transition probabilities. The harmonic oscillator. The hydrogen atom. Quantum aspect of electromagnetic radiation, quantum electrodynamics. Nuclear interactions, stable and unstable nuclei. Elementary particles – their production and interactions.

PHY 282F INTRODUCTION TO MODERN PHYSICS

II – 8; II – 2, 4, III – 4 (elective) 3 – – 8

The principles of modern physics with emphasis on applications to engineering. Specific topics include: the interaction of electromagnetic radiation with matter; crystal structure from diffraction (x-rays, etc.); the nuclear reactor; radioactivity and the ages of minerals, ocean sediments, artifacts; the laser and the maser; superconductors and superfluids. Reference: Oldenberg and Rasmussen – *Modern Physics for Engineers*. *N. Edwards*

PHY 282S INTRODUCTION TO MODERN PHYSICS

II – 1, II – 4, III – 4 (elective) 3 – – 8

Same as PHY 282F.

PHY 283F BASIC CLASSICAL AND MODERN PHYSICS

II – 2, II – 4, III – 4 (elective) 3 – – 8

A review of dynamics emphasizing the energy-momentum point of view and conservative systems; Rotational dynamics, planetary motion, motion in noninertial frames; oscillatory and wave motion; thermal physics including free energies and entropy; an introduction to quantum phenomena, radioactivity; basic explanations for the thermal, deformational and electrical properties of materials.

PHY 326F MODERN PHYSICS LABORATORY

III – 5p – 6 – 10

Experiments of both a pure and applied nature are available in the areas of atomic, molecular, solid state, nuclear and particle physics. The experiments are open-ended; the student may spend more or less time on any particular experiment depending on his particular interest. The laboratory is open five days a week. Demonstrators will be in the laboratory at the times shown in the time-table and available for consultation at othe times. Registration at the Physics office first week of term. (Prerequisite: PHY 180F 181S, 280F, 281S).

PHY 326S MODERN PHYSICS LABORATORY

III – 5p (elective) – 6 – 1

This is a continuation of PHY 326F.

PHY 332F MOLECULAR BIOPHYSICS

III – 5p (elective) 2 – –

The physical and chemical properties of some biologically important macromolecules i relation to their functions. Techniques, such as sedimentation, chromatography, spec troscopy, scattering of photons and electrons. The course is designed to give studen with a physics and chemistry background an insight into the application of the exa sciences to the solution of biological problems. (Prerequisite: PHY 180F, 181S, 280F, 281S) (*Not offered in 1974–75*)

PHY 333S CELLULAR BIOPHYSICS

III – 5p (elective)

2 – – 8

The emphasis will be on the application of principles from physics, chemistry and genetics to quantitative studies in cell biology. Selected areas in biophysics such as cellular differentiation, the regulation of macromolecular biosynthesis, and the application of biophysical methods to problems in medicine, will be discussed in detail. (Prerequisite: PHY 180F, 181S, 280F, 281S). (*Not offered in 1974–75*)

PHY 334F INTRODUCTION TO SOLID STATE PHYSICS

III – 5m; 5p, 8 (elective)

2 – – 8

Introduction to the basic features of solid state physics including: crystal lattices, their structure and description; propagation of waves in periodic structures, including x-rays and neutron diffraction; properties of phonons and the behaviour of electrons in crystalline solids; the principal properties of metals, semi-conductors and insulators; the features of the magnetic behaviour of metals. (Prerequisite: PHY 180F, 181S, 280F, 281S)

F. D. Manchester

PHY 335F INTRODUCTION TO NUCLEAR PHYSICS

III – 5nt; 5p (elective)

2 – – 8

Important discoveries in nuclear and particle physics. Properties of the nucleus and of nuclei. The measurement of atomic masses; nuclear binding energies, binding energy and mass formulas, liquid drop and fission. Introduction to nuclear shell and collective models. Interaction of charged particles and uncharged particles with matter; particle detection, energy and momentum measurements. Radioactive decay phenomena: Theory and experiment. Nuclear reactions and cross sections. Particle accelerators. (Prerequisite: PHY 180F, 181S, 281F, 281S)

R. E. Azuma

PHY 336S APPLIED NUCLEAR PHYSICS

III – 5m, 5nt, 5p (elective)

2 1 – 8

Fission and fusion. Tracer techniques. Biological effects of radiation. Applications of nuclear techniques in various fields. Neutron and scintillation radiography. Activation analysis. Those taking PHY 325/326Y/328S concurrently meet the laboratory requirement. This course makes use of the materials contained in PHY 335F. (Prerequisite: PHY 180F, 181S, 280F, 281S, 335S)

PHY 337S ELEMENTARY PARTICLE PHYSICS

III – 5p (elective)

2 – – 8

A contemporary picture of the world of elementary particle physics. Introduction to the classification of particle states, types of interactions, experimental methods, conservation laws and invariance principles. Discussions to include weak, electromagnetic and strong interactions and to point out the unsolved problems that are currently being investigated. (Prerequisite: PHY 180F, 181S, 280F, 281S)

J. D. Prentice

PHY 338X EXPLORATION GEOPHYSICS

IV – 2A; 2C (elective) 2 3 – 8, 2 3 – 8

An introduction to the physical principles underlying the important methods of geophysical prospecting. Particular attention is given to seismic, gravitational, magnetic and electromagnetic methods. Textbook: Dobrin, *Introduction to Geophysical Prospecting*. *N. Edwards*

PHY 353F THERMODYNAMICS

III – 5p (elective) 2 – – 8

The general principles of classical thermodynamics are discussed and related to statistical physics. Representative applications in fluids, solids, magnetic systems and phase transitions are considered. (Prerequisite: PHY 180F, 181S, 280F, 281S) *E. Fawcett*

PHY 382S QUANTUM AND STATISTICAL MECHANICS

III – 5nt, 5p; 5a, 5e, 5g (elective) 3 – – 8

Time independent and time dependent perturbation theory. Transition probabilities. Multielectron atoms. Classical Maxwell-Boltzmann statistics. Bose-Einstein and Fermi Dirac Statistics. Statistical thermodynamics. This course builds on the material contained in PHY 181S and PHY 281S. (Prerequisite: PHY 180F, 181S, 280F, 281S) *L. Trainor*

PHY 384F THERMODYNAMICS AND STATISTICAL MECHANICS

III – 7 3 – 1 8

A statistical approach will be used to discuss the behaviour of physical systems leading in a natural way, with a minimum of formality, to general thermodynamics. Throughout the course, a microscopic approach interpreted in terms of quantum ideas will be emphasized. Many developments and illustrations will be in terms of magnetic spin systems for instance. Examples and applications of interest in dealing with electromagnetic systems will be given. Textbook: C. Kittel, *Thermal Physics*. *F. D. Manchester*

PHY 422F TIME SERIES ANALYSIS LABORATORY

IV – 5g – 6 – 8

A laboratory concerned with mathematical and computational techniques for the analysis of discrete data series. Topics include Fourier, z and Laplace transforms in continuous and discrete representations, aliasing effects of sampling continuous functions, convolution and correlation, bandpass and optimum least squares, filtering and estimation of power spectra. The course is particularly relevant to geophysical data analysis. Textbook: *Fourier Analysis*. (Prerequisite: Open only to IV – 5G)

PHY 426F QUANTUM PHYSICS LABORATORY I

IV – 5p (elective) – 6 – 8

This laboratory is basically a continuation of PHY 327F. Experiments similar to those of PHY 327F are available but at a more advanced level. In addition several experiments of a research nature may be undertaken outside the laboratory. The laboratory is open five days a week. Demonstrators will be available in the lab at times shown in the timetable and available for consultation at other times. Registration at the Physics office first week of the term. (Prerequisite: PHY 327F, 382S)

PHY 426S QUANTUM PHYSICS LABORATORY II

IV – 5p (elective) –6–8

This laboratory course is provided to allow the student to conduct experiments of a research nature under the direct supervision of a member of the Physics staff. In some cases, with the permission of the Chairman of Engineering Science, this project may be combined with the thesis APS 498S. A student wishing to enrol in this course is expected to seek out a supervisor of his choice and to choose a problem that is acceptable both to himself and to the staff member. A list of available staff and possible projects may be obtained from the Physics office. (Prerequisite: PHY 382S)

PHY 442 PHYSICS OF THE EARTH

III –5g 2––7, 2––7

A course providing a physical background for the study of the interior of the earth and the moon, and the development of their surface features. Topics include seismic waves and the earth's structure, the gravitational field and the earth's mass distribution, geomagnetism, geochronology, and the mechanical and thermal properties of the earth's interior. Recent results from the Apollo Missions will be discussed. Textbook: Garlan, *Physics of the Earth*; Mantle, *Core and Crust*; Stacey, *Physics of the Earth*. (Prerequisite: Open only to III, IV– 5g)

D. York

PHY 443X THEORY AND APPLICATION OF GEOPHYSICAL METHODS

IV – 5g 23–11, 23–11

The lectures stress the physical and mathematical theories of seismic, magnetic, electrical and gravitational methods. Considerable emphasis is placed on Fourier transform methods. The laboratory program stresses the practical methodology and will consist of a 10 day field camp held just before term begins. The cost of food and transportation for this camp will not exceed $40 per student. During term the data taken in the field camp will be interpreted. Textbook: Grant and West, *Interpretation Theory in Applied Geophysics*; Griffiths and King, *Applied Geophysics*.

N. Edwards

PHY 450C, PHY 450D QUANTUM THEORY I AND II

IV – 5p (elective) 2––8, 2––8

Hermitean operators, Hilbert space, commutators, r and p representations. Second quantization of harmonic oscillator, coherent states. Classical correspondence, Ehrenfest's principles, continuity equations. Central forces, angular momentum, spherical harmonics. Variational principle. W. K. B. approximation. Scattering theory, phase shifts, spherical Bessel functions. Matrix methods. Heisenberg's equations of motion.

Spin Coupling of angular momentum, CG coefficients, rotations. Perturbation theory, Golden rule, EM transitions. Identical particles, determinants, second quantization. Klein Gordon and Dirac relativistic wave equations.

PHY 451C, PHY 451D STATISTICAL MECHANICS I AND II

IV – 5p (elective) 2--8, 2--8

Microcanonical, canonical, and grand canonical distributions, Bose Einstein and Fermi Dirac Statistics. Applications to liquid helium, plasmas, phonons, photons and lattice gas. Mean field approximation for phase transitions (magnetic systems and gas-liquid transition). Theory of imperfect gases. Density fluctuations. Correlation functions. Kinetic theory of gases and application to irreversible phenomena. Derivation of Boltzmann transport equation for binary collisons and its solution. (Prerequisite: PHY 382S)

PHY 452C, 452D RELATIVITY THEORY I AND II

IV – 5p (elective) 2--8, 2--8

Special theory: Principle of relativity, Lorentz transformations, Minkowski space, tensor algebra. Relativistic particle dynamics, collision theory. Relativistic field theory, hydrodynamics, Maxwell field, electrodynamics of material bodies, Klein Gordon field. General theory: principle of equivalence, general covariance, tensor analysis. Einstein equations, Schwarzschild solution, geodesics, gravitational collapse, black holes. Geomodels, Robertson-Walker metric, mix master universe. (Prerequisite: PHY 382S) *J. Moffat*

PHY 453C, PHY 453D NUCLEAR PHYSICS I AND II

IV – 5p (elective) 2--8, 2--8

General properties of nuclei and nucleons. Nuclear masses, nuclear binding energy. Nuclear structure, meson theory and quark model. Nucleon-nucleon scattering phenomenology and the nucleon-nucleon force. The deuteron. Shell and collective models of nuclear structure. Nuclear reactions. Alpha decay. Fission. Electromagnetic interactions: gamma decay, photonuclear reactions, electron scattering and electrodisintegration. Weak interactions: beta decay, inverse beta decay. Parity non-conservation and related phenomena. (Prerequisite: PHY 382S)

PHY 454C, PHY 454D HIGH ENERGY PHYSICS I AND II

IV – 5p (elective) 2--8, 2--8

Introduction to concepts and experimental methods of high energy or particle physics, with an emphasis on phenomenology. Topics include: particle accelerators and detectors, conservation laws and invariance principles in weak, electromagnetic and strong interactions, scattering theory, the production and decay of boson and baryon resonances, unitary symmetry and particle classification. (Prerequisite: PHY 382S) *A. W. Key*

PHY 455C, PHY 455D SOLID STATE PHYSICS I AND II

IV – 5p (elective) 2--8, 2--

Crystal lattices, including lattice energies; wave propagation in periodic structures including diffraction; phonons, thermal properties of solids, including specific heats, free electron theory, energy bands, Fermi surfaces, electronic transport properties, homogenerous semiconductors, superconductivity, magnetism in solids. (Prerequisite: PHY 382S)

PHY 456C, PHY 456D MODERN OPTICS AND RADIATION I AND II

IV – 5p (elective) 2 – – 8, 2 – – 8

Production and propagation of electromagnetic radiation. Vectorial nature of light. Coherence and interference including holography and the diffraction of x-rays. Optics of solids including nonlinear optics. Masers and lasers. Scattering of light – Rayleigh, Brillouin and Raman. Magnetic resonance NMR, EPR, NQR. (Prerequisite: PHY 382S)

PHY 457F GROUP THEORY AND ITS PHYSICAL APPLICATIONS I

IV – 5p (elective) 2 – – 8

Elements of abstract group theory, group representations – reducible and irreducible, group characters and orthogonality relations, applications of representation theory in quantum mechanics, point groups, space groups, the three dimensional space groups, the classification of functions by transformation properties, crystal field splitting of atomic energy levels, group theoretical matrix element theorems, group theory and directed valence. *R. L. Armstrong*

PHY 458S GROUP THEORY AND ITS PHYSICAL APPLICATIONS II

IV – 5p (elective) 2 – – 8

The application of the techniques of group theory to several detailed topics taken from the fields of atomic, molecular and solid state physics. This course makes use of the material contained in PHY 457F. (Prerequisite: PHY 382S) *H. L. Welsh*

PHY 480F MODERN PHYSICS

IV – 3 3 – 19

A discussion of the fundamental principles in atomic and nuclear physics. Emphasis will be given to the application of these principles in branches of modern engineering. Topics will include basis quantum mechanics, atomic and nuclear structure, solid state and the interaction of radiation with matter. Specific items such as lasers and the nuclear reactor will be discussed. *G. M. Graham*

STATISTICS
(Department of Mathematics)

STA 282S PROBABILITY AND STATISTICS

II – 3, 8; II – 2, III – 2C (elective) 2 – 28

Elements of probability theory. Binomial, Poisson and normal distributions. Sampling theory. Significance tests. Control charts. Least squares. *S. K. Sinha*

STA 287S PROBABILITY AND STATISTICS

II–5 3–18

Definition of probability; binomial, Poisson, and normal distributions; frequency; sampling distributions. Examples of estimation, hypothesis testing, control charts, regression, and analysis of variance. *M. Srivastava*

STA 291F PROBABILITY

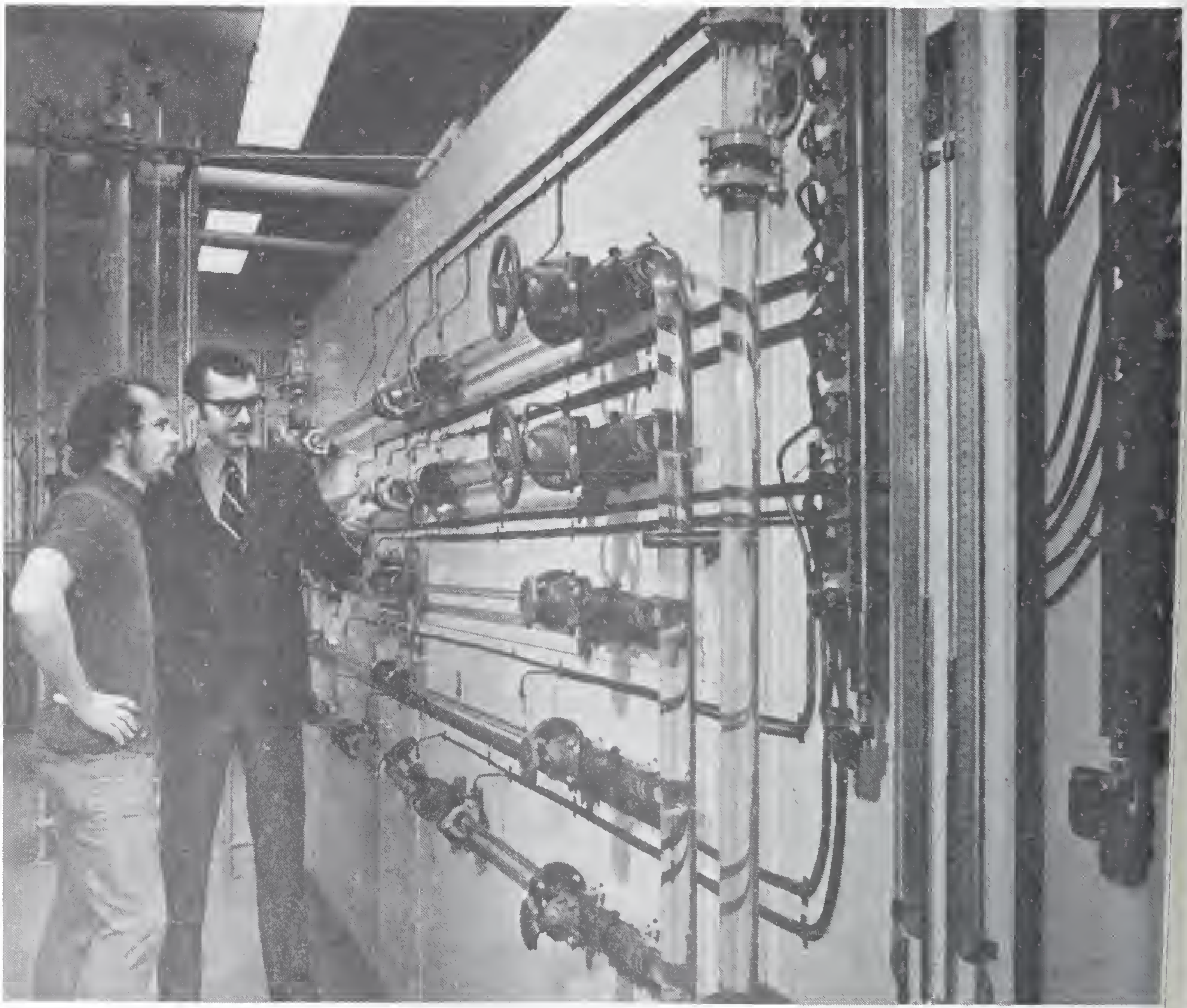
II–4 2–28

Elements of probability. Random variables. Discrete and continuous distributions. Moments. Independence. Conditional probabilities. Theory of sampling. (Prerequisite: MAT 186F, MAT 187S) *Y. S. Lee*

STA 292S STATISTICS

II–4 2–28

A continuation of STA 291F. Tests of significance and confidence limits. Control charts. Introduction to the analysis of variance, design of experiments and regression. (Prerequisite: STA 291F) *Y. S. Lee*



VII

General Regulations; Examinations

The curriculum is based on a term system in which all courses of instruction (with the exception of certain courses taken in the Faculty of Arts and Science) are one term in duration. There are two terms in the annual session, each concluding with final examinations in the courses offered. With the exception of the First Year, for which there are special provisions, students will be evaluated for promotion at the end of each term.

A regular program consists of a maximum of six courses per term with a total weight of 48 units; with the approval of the Chairman of his Department a student enrolled in the second or higher years may elect to reduce his load to a minimum of 40 units per term, or to increase it to a maximum of 60 units. First Year students may not take less than the normal load of 48 units.

I. DEFINITIONS

Fall Term Average – is calculated on the basis of all courses in which the student is enrolled at the start of the eighth week of the term, with the weighting factor for each course being the units assigned to it. The results of summer* or pre-session courses taken for credit will be included in the calculation of the Fall Term Average with their full unit value. The results of full-year courses taken in another Faculty will not be included in the calculation of the Fall Term Average, except in the case of certain courses for which arrangements have been made for the submission of marks on a term basis.

Spring Term Average – is calculated on the basis of all courses in which the student is enrolled at the start of the eighth week of the term with the weighting factor for each course being the units assigned to it. The results of full-year courses in which there are no mid-year evaluations will be included in the calculation of the Spring Term average with a weight equal to the spring term weight only. When the Fourth Year Thesis is spread over two terms and a department elects to report marks only at the end of the second term, the mark will have a weight equal to the sum of the Thesis weights for the two terms.

*Approval to take a summer course for credit must be obtained in advance by writing to the Secretary, Faculty of Applied Science and Engineering.

Year Average – is computed on the basis of the final marks and weights of all courses in which the student was enrolled in both terms, the weight of full-year courses being the sum of the term weights.

Core Course – Any course in a program that is so designated by a Department.

Evaluation Period – the Fall and Spring Terms taken together is the principle evaluation period for students who are taking First Year for the first time. For all other students, the evaluation period is a single term.

II. REGULATIONS

1. To qualify for a degree, a student must complete a full undergraduate program.

2. (*a*) The normal load is 48 units per term but a student may reduce his load to approximately 40 units or increase it to 60 units if his Department Chairman approves.

(*b*) Certain students are not permitted to reduce their academic loads, viz. students in First Year for the first time, or students who are required to repeat all of the courses in a term of one of the prescibed departmental programs.

(*c*) Students required to repeat courses and to whom regulation 2. (b) does not apply must carry a reduced load of approximately 40 units per term.

(*d*) In the final term a student may carry less than the normal minimum load of 40 units if the aggregate weight of the courses required for completion of his program is less than 40 units.

3. A student taking the First Year Engineering curriculum who:

(*a*) Obtains a Fall Term Average of 50% or greater proceeds to the next term.

(*b*) Obtains a Fall Term Average less than 50% is required to withdraw. (See regulations 7 and 8)

(*c*) Obtains a Year Average of 60% or greater proceeds to the next term.

(*d*) Obtains a Year Average in the range of 55% to 59% proceeds to the next term and is placed on probation.

(*e*) Obtains a Year Average in the range of 50% to 54% must repeat* all courses (from both terms) in which he obtained less than 60 marks, and is placed on probation.

(*f*) Obtains a Year Average lower than 50% is required to withdraw. (See regulations 7 and 8)

4. A student taking the First Year Engineering Science curriculum who:

(*a*) Obtains a Fall Term Average of 55% or greater proceeds to the next term in the Engineering Science curriculum.

(*b*) Obtains a Fall Term Average in the range of 50% to 54% must transfer to another engineering program, and proceeds to the next term in the Engineering curriculum.

(*c*) Obtains a Fall Term Average less than 50% is required to withdraw. (See regulations 7 and 8)

(*d*) Obtains a Year Average of 66% or greater proceeds to the next term in Engineering Science.

(*e*) Obtains a Year Average in the range of 55% to 65% may not continue in Engineering Science, but may proceed to the next term in any other engineering program in the Faculty.

(*f*) Obtains a Year Average in the range of 50% to 54% may not continue in Engineering Science, but may proceed on probation to the next term in any other engineering program in the Faculty.

(*g*) Obtains a Year Average less than 50% is required to withdraw. (See regulations 7 and 8)

5. Any student not covered under Section 3 or 4 who:

(*a*) Obtains a Term Average of 60% or greater proceeds to the next term and, if applicable, is removed from probation.

(*b*) Obtains a Term Average less than 60% but greater than or equal to 55% proceeds to the next term if not already on probation, and is placed on probation.

(*c*) Obtains a Term Average less than 55% but greater than or equal to 50% and is not already on probation is placed on probation and must repeat* all courses taken in that term for which his marks were less than 60%. Normally any student in this category who must repeat more than two of his technical courses will be required to withdraw for one term.

(*d*) Obtains a Term Average less than 50% will be required to withdraw. (See regulations 7 and 8.)

(*e*) To be eligible for graduation a student must attain an average not lower than 60% in his final term; a student who fails to do so must repeat or replace courses to bring his average up to at least 60%.

6. A student will also be required to withdraw from the Faculty if:

(*a*) He is on probation and fails to obtain at least a 60% average so as to remove himself from probation.

(*b*) He has been placed on probation twice before and obtains an average which would place him on probation again.

7. A student who has been required to withdraw for the first time may apply for re-admission under the conditions following:

(*a*) A student who has been required to withdraw as a consequence of his standing in the work of a term (Fall or Spring) may apply for re-admission to the corresponding term in the next session or in a subsequent session.

(*b*) A student who has been required to withdraw as a consequence of obtaining an average lower than 50% on the work of the First Year may not apply for re-admission until one full session has elapsed.

(*c*) Each application for re-admission is considered on its merits, in competition with all other applications.

(*d*) A student who has been required to withdraw from the First Year Engineering Science program will not normally be re-admitted to the Engineering Science program, but will be considered for re-admission to any other engineering program.

(*e*) If re-admitted, the student is placed on probation and is required to repeat* all courses (or their equivalents) in which he obtained less than 60 marks in his last evaluation period.

8. A student who is required to withdraw for the second time will not normally be re-admitted.

9. A student required to repeat courses can make up his academic load of approximately 40 units per term in the following ways, provided that his selection creates no timetable conflicts:

(*a*) By taking courses from the next higher year of the program if he has obtained a mark of 50% or greater in the appropriate prerequisite taken in his previous evaluation period.

(*b*) By taking courses of comparable level to his failed courses. Normally these will not relieve the student of completing all the required courses in the program in which he is enrolled.

(*c*) By repeating courses which he has previously completed.

*Courses which are not designated as core courses need not be repeated but can be replaced by a course of comparable level.

GRADING SYSTEM

1. The student's work in individual courses is graded in the following manner:

Marks	*Grade*
80 – 100%	1
70 – 79%	2
60 – 69%	3
50 – 59%	4
Below 50%	5

2. Honour standing in the work of a term or a year is granted to students who achieve a weighted average of 75% or greater.

3. Honour graduate standing will be granted to students who obtain honours in the final year and in any one previous year.

CHECKING OF MARKS

It is a policy of the Faculty that no examination papers or essays will be re-read or re-evaluated after the results have been issued. All results are carefully reviewed before being released. However, the clerical work involved in the examining department and in the Faculty Office will be checked upon written request to the Secretary of the Faculty of Applied Science and Engineering. The request must be accompanied by a fee of $5 for each paper to be checked. The fee will be refunded if an error is found.

ATTENDANCE

1. Students proceeding to the degree are required to attend the courses of instruction and the examinations in all subjects prescribed. A student whose attendance or work is deemed by the Council of the Faculty to be unsatisfactory may have his registration cancelled at any time.

2. Students must conform to all lecture room and laboratory regulations. Reports,

briefs, theses and drawings become the property of the Council to dispose of as it may see fit. Drawings, briefs and field notes will not be accepted unless they have been made at the time and place provided in the timetable.

APPEALS

1. A student should submit immediately after its occurrence, evidence of any illness or mishap which occurs during the term; any petition for leniency on account of such incidents may be refused consideration if received after the third day following the last day of examinations.

2. A student wishing to appeal against a decision of a Committee of Council should consult the Secretary of the Faculty for information regarding the appeal processes available within the Faculty.

3. A student wishing to appeal to the Governing Council against a decision of the Council of the Faculty should consult the Secretary of the Faculty or the Secretary, Sub-Committee on Academic Appeals, Office of the Governing Council about the preparation and submission of his petition to the Secretary of the Governing Council.

EXTRA-CURRICULAR ACTIVITIES AND ACADEMIC CREDIT

It is in general desirable for students to engage to a reasonable extent in extra-curricular activities in order that they may not become too narrowly professional in interests and outlook, but it will be obvious that no academic credit or consideration can be given for such activities. Some offices in student organizations require quite large amounts of time for the proper performance of the duties connected with them, and it is therefore strongly recommended that students, particularly those whose academic records are not high, consult a senior member of staff before allowing themselves to be nominated for such offices.

VIII

Medals, Prizes, Scholarships and Bursaries

Through the generosity of friends of the University, governments and commercial organizations, encouragement has been given to undergraduate work in the various branches of engineering study by the establishment of the scholarships, prizes, bursaries and medals listed in the following pages.

ADMISSION SCHOLARSHIPS AND BURSARIES

Ontario Students:
Scholarships and bursaries available to students entering the First Year are listed on page 176. For full details concerning these awards, applicants should consult the Calendar of Admission Awards, which is available at Secondary Schools or from the Office of Student Awards, Simcoe Hall, University of Toronto. Applications, which must be made through the Principal of the Secondary School, close on April 19 annually.

Non-Ontario Students:
All non-Ontario students should apply to the Office of Student Awards, Simcoe Hall, University of Toronto. A limited number of scholarships is reserved for students living outside the Province of Ontario, but as competition is keen such students must not count on receiving assistance but are advised rather to ensure that they have sufficient funds from their own government or from private sources to cover all probable expenses.

IN-COURSE SCHOLARSHIPS AND BURSARIES

Scholarships, prizes, bursaries and loans available to students in attendance in the Faculty are listed on pages 176 to 179. Where it is necessary to make application for an award it is so stated in the description and particulars are given as to how the application should be made. In all other cases the award is made on the recommendation of the Faculty Council and no application is necessary.

GENERAL TERMS AND CONDITIONS

Scholarships, prizes and medals granted in recognition of academic proficiency are awarded at the end of the Spring Term, the candidates being ranked on the basis of their achievement in the Spring Term and the Fall Term previously completed.

To be eligible for any scholarship or award granted solely on academic standing a student must have completed not less than the normal full load within the two terms upon which the award is based. A student whose program in these two terms contains repeated courses will only be eligible if his aggregate of new courses is equal to or greater than 96 units.

Unless otherwise specified in the terms of award, scholarships, medals and prizes based solely upon academic standing will be awarded only to students who have achieved honours in the work upon which the award is granted. If the award is based on a single course or on a part of the work of the term, the candidate must obtain unconditional pass standing in the work of the term, but need not obtain honours on the work of the term unless the terms of the award so specify.

A candidate will not be permitted to hold more than one award in a session unless the statute of each of the awards concerned or the Calendar specifies otherwise. Only one of those awards marked with an asterisk may be held in any one year.

Medals, after they have been suitably engraved, will be given without delay to the winners or forwarded to them by registered mail.

Awards granted to members of graduating classes other than awards for graduate study and research, will be paid in one instalment as soon as possible after the granting of the awards.

All other awards will be paid (i) if of the value of $100 or less, in one instalment on November 20 and (ii) if of the value of more than $100 in two equal instalments, the first on November 20 and the second on January 20, in the session following the granting of the awards. Payment will be made only if the candidate is in regular attendance in the Faculty and, if the Calendar so specifies, in the course in which the award is established or granted.

The Governing Council may, on the recommendation of the Faculty, permit a candidate to whom an award has been granted to postpone attendance upon lectures and laboratory classes for one year. Further postponement may be permitted on application.

NOTE – As the value of an endowed scholarship or prize is dependent on the actual income of the fund, it is possible that the value of certain scholarships and prizes at the time of payment may be greater or less than the amount stated in the calendar.

In those cases where the amount of the award is not payable from income earned on an endowed fund, payment will be dependent on the receipt of the amount of the annual award from the donor.

AVAILABLE TO STUDENTS ENTERING THE FIRST YEAR

(† *indicates that application is required*)

Alumni Association War Memorial Scholarships	†	$500	page 205
J. P. Bickell Foundation Scholarships	†	$500	183
J. W. Billes Admission Scholarships	†		189
Children of War Dead Education Assistance	†		186
Engineering Alumni Centennial Admission Scholarships (7)	†	$1000	188
Grabill Admission Scholarship	†	$ 500	190
Hagarty Memorial Scholarship	†	$ 60	191
The Murray Calder Hendry Scholarship	†	$ 500	192
Roy Jarvis Henry Admission Scholarships (3)	†	$ 500	192
J. Edgar McAllister Foundation Admission Awards (25)	†	$1000	193
Lachlan Dales McKellar Admission Scholarships (2)	†	$ 500	195
George R. Mickle Admission Bursaries	†	$1000	197
O.H.A. War Memorial Scholarship	†	$ 200	198
Ontario Chapter American Society for Metals Bursaries	†	$ 150	181
Ontario Student Assistance Program	†		198
A.P.E.O. Admission Scholarship	†	$ 500	199
Regular Officer Training Plan	†		201
Helen E. Rogers Admission Scholarships	†		201
Simpsons-Sears Limited (Northern Ontario) Scholarship	†	$ 100	203
Walter Sterling Admission Scholarships	†		204
Wallberg Admission Scholarships (6)	†	$1000	206

AVAILABLE TO STUDENTS COMPLETING THE FIRST YEAR

(† *indicates that application is required*)

Baptie Scholarship		$ 175	182
Canadian Bechtel Limited Bursaries	†		183
J. P. Bickell Foundation Scholarships			183
T. H. Bickle Prize		$ 30	184
Crocker Foundation Bursaries	†		187
John M. Empey Scholarship		$ 170	188
Engineering Society Centennial Award		$ 100	189
The George A. Guess Scholarships			191
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		192
Johnson's Wax Scholarship		$ 800	193
*J. Edgar McAllister Foundation Undergraduate Awards		$1000	194
Garnet W. McKee-Lachlan Gilchrist Scholarship in Engineering Science		$ 110	194
MacLennan – MacLeod Memorial Prize		$ 25	196
Ontario Chapter American Society for Metals Bursaries	†		181

Ontario Student Assistance Program	†		198
Paulin Memorial Scholarship		$ 600	198
Procter and Gamble Bursary	†		199
*Professional Engineers Scholarship		$ 250	199
Ransom Scholarship in Chemical Engineering		$ 325	200
Frederick W. Schumacher Scholarship	†		202
S. Ubukata Fund	†		205
*Wallberg Undergraduate Scholarships (2)		$ 500	206
Stewart Wilson Award	†		206

AVAILABLE TO STUDENTS COMPLETING THE SECOND YEAR

(† *indicates that application is required*)

Harvey Aggett Memorial Scholarship		$ 90	180
Ardagh Scholarship		$ 600	181
A.S.H.R.A.E. Bursaries	†		181
Automotive Transport Association Bursary	†		182
Babb Bursary Fund	†		182
Canada Student Loans	†		189
Canadian Bechtel Limited Bursaries	†		183
J. P. Bickell Foundation Bursaries	†		184
J. P. Bickell Foundation Scholarships			183
T. H. Bickle Prize		$ 30	184
Carveth Metallurgical Ltd. Bursary	†	$ 500	185
5T6 Civils Scholarship	†	$ 200	186
Crocker Foundation Bursaries	†		187
Cyanamid of Canada Scholarship		$ 750	187
John M. Empey Scholarship		$ 170	188
Engineering Alumni Centennial Bursaries	†		188
Engineering Society Centennial Award		$ 100	189
J. A. Findlay Scholarship		$ 100	189
Hugh Gall Award		$ 300	190
*General Motors Scholarships		$1000	190
Hydro-Electric Power Commission of Ontario Bursary	†	$ 500	192
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		192
J. Edgar McAllister Foundation Bursaries	†		193
*J. Edgar McAllister Foundation Undergraduate Awards		$1000	194
Charles Gordon Manning Prize			196
James L. Morris Memorial Prize		$ 175	197
Ontario Chapter American Society for Metals Bursaries	†		181
Ontario Chapter American Society for Metals Scholarship			181
Ontario Student Assistance Program	†		198
*Professional Engineers Scholarship		$ 250	199

*Rhodes Scholarship	†	£1000	200
Frederick W. Schumacher Scholarship	†		202
Edith Tyrrell Memorial Bursary	†	$ 600	204
Wallberg Undergraduate Scholarship		$ 500	206
William R. Worthington Memorial Scholarship		$ 600	207

AVAILABLE TO STUDENTS COMPLETING THE THIRD YEAR

(† *indicates that application is required*)

American Institute of Industrial Engineers Scholarship		$ 150	180
A.S.H.R.A.E. Bursaries	†		181
Babb Bursary Fund	†		182
F. W. Baldwin Prize		$ 75	182
Canada Student Loans	†		189
Canadian Bechtel Limited Bursaries	†		183
J. P. Bickell Foundation Bursaries	†		184
T. H. Bickle Prize		$ 30	184
*Chevron Standard Limited Scholarship		$ 500	185
Chemical Institute of Canada Prize		$ 25	185
Cominco Scholarships	†	$ 800	186
Sydney C. Cooper Bursaries	†		186
Crocker Foundation Bursaries	†		187
The Culliton Scholarship		$ 300	187
Dow Chemical of Canada Limited Award		$ 500	187
John M. Empey Scholarship		$ 170	188
E.I.C. Prize		$ 100	189
Engineering Alumni Centennial Bursaries	†		188
Engineering Society Semi-Centennial Award		$ 100	189
J. A. Findlay Scholarship		$ 100	189
James Franceschini Foundation Scholarship		$ 300	190
*General Motors Scholarship		$1000	190
The George A. Guess Scholarship			191
Chester B. Hamilton Scholarship		$ 500	191
I.B.M. – Thomas J. Watson Memorial Bursary Fund	†		19
*Jenkins Scholarship in Engineering		$ 200	19
Loan Funds	†		20
J. Edgar McAllister Foundation Bursaries	†		19
*J. Edgar McAllister Foundation Undergraduate Awards		$1000	19
J. A. D. McCurdy Prize		$ 75	19
Alexander MacLean Scholarship		$ 250	19
Ontario Chapter American Society for Metals Bursaries	†		18
Ontario Chapter American Society for Metals Scholarship			18

Ontario Student Assistance Program	†		198
*Professional Engineers Scholarship		$ 250	199
RCE Memorial Scholarship	†	$ 125	201
Rosedale Chapter, I.O.D.E. Award	†	$ 400	202
Don Salt Memorial Scholarships	†	$ 500	202
Murray F. Southcote Scholarship		$ 100	204
Frederick W. Schumacher Scholarship	†		202
Edith Tyrrell Memorial Bursary	†	$ 600	204
Wallberg Undergraduate Scholarship		$ 500	206
C. H. E. Stewart Bursaries	†		204

AVAILABLE TO STUDENTS COMPLETING THE FOURTH YEAR

(† *indicates that application is required*)

Henry G. Acres Medal			180
American Society of Lubrication Engineers Prize		$ 75	181
J. P. Bickell Foundation Bursaries	†		184
Babb Bursary Fund	†		182
Canada Student Loans	†		189
Centennial Thesis Awards		$ 50	185
Sydney C. Cooper Bursaries	†		186
Crocker Foundation Bursaries	†		187
Electrical Manufacturing Co. Limited – Montel Inc. Prize		$ 50	188
Loan Funds	†		207
J. Edgar McAllister Foundation Bursaries	†		193
Massey-Ferguson Ltd. Scholarships (2)	†	$ 500	197
Ontario Student Assistance Program	†		198
Otto Holden Scholarship		$ 900	197
Professional Engineers Gold Medal			199
J. E. Reid Memorial Prize		$ 50	200
Wallace Award, Society of Automotive Engineers Prize		$ 100	203
Society of Chemical Industry Merit Award			204
"Second Mile Engineer" Award	†	$ 200	202
W. S. Wilson Medals			207

HENRY G. ACRES MEDAL

The Henry G. Acres Medal is the gift of Mrs. Henry G. Acres in memory of her late husband, Henry G. Acres, M.E., D.Sc., a graduate of the School of Practical Science in the class of 1903. Throughout his professional life Dr. Acres was associated with major power developments in Canada and abroad. As chief hydraulic engineer for the Hydro-Electric Power Commission of Ontario in the period 1911 to 1923, he was responsible for the design and construction of nearly twenty power plants, including the Queenston-Chippewa development. Entering private practice in 1924, and until his death in 1945, he continued to widen and extend his interests. He became chief engineer of the Grand River Conservation Commission and responsible for the design and construction of the Shand dam and related work. Later, he was consulting engineer for the extensive power developments at Shipshaw on the Saguenay River, which was vital to the production of aluminum for war purposes. Many of the provinces of Canada sought his services and he advised with respect to work in Newfoundland, South America and India.

This medal is awarded annually to the student in the Fourth Year who is registered in the course in Civil, Mechanical, or Electrical Engineering, and who obtains the highest aggregate percentage at the annual examinations of the Third and Fourth Years, provided always that the student obtains honour standing in the examinations of the Fourth Year. Receipt of the medal does not preclude a student from being granted such other award as may in the opinion of the Council be appropriate.

HARVEY AGGETT MEMORIAL SCHOLARSHIP

This scholarship was donated by the late Mr. J. T. Aggett, of Toronto, as a perpetual memorial to his son, the late Lieutenant Harvey Aggett, who enlisted in March, 1915, during his second year in this Faculty, and was killed in action at Passchendaele on November 6, 1917.

This annual scholarship of the value of the annual income from the fund is to be awarded to a student of the Second Year in this Faculty who, obtaining honours and being one of the first three in his year by his standing at the annual examinations, has been adjudged highest of the three in general student activities and service in the University during his period of attendance. When regulations do not permit the winner to hold this scholarship the students to be considered for the award shall be the first three in the year exclusive of any student who holds a scholarship of higher value.

AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS SCHOLARSHIP

The Toronto Chapter, American Institute of Industrial Engineers offers a scholarship o $150 to a student entering the Fourth Year of the Industrial Engineering course. Th student must have consistently maintained high, though not necessarily honour standing during the previous three years, and must be an active member of the University o

Toronto Student Chapter of A.I.I.E. The selection will be made on the recommendation of the Chairman of the Department of Industrial Engineering.

A.S.H.R.A.E. BURSARIES

The Ontario Chapter of the American Society of Heating, Refrigerating and Air Conditioning Engineers provides a number of bursaries, to a total value of $1500 annually, for students in the Second and Third Years of Electrical Engineering and Mechanical Engineering. Candidates must reside in Metropolitan Toronto or in an adjacent municipality; the awards will vary in value, according to individual need and the fund available. Application should be made to the Secretary of the Faculty by November 15, on the regular in-course bursary application form.

AMERICAN SOCIETY OF LUBRICATION ENGINEERS PRIZE

The Toronto section of the American Society of Lubrication Engineers offers an annual prize of $75 to a student in the Fourth Year in Mechanical Engineering whose Thesis dealing with Lubrication is considered by the Head of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory. The Prize is accompanied by a donation of $25 to the Department to purchase books on Lubrication.

ONTARIO CHAPTER, AMERICAN SOCIETY FOR METALS BURSARIES

The Ontario Chapter, American Society for Metals, provides several bursaries of a value of $150 each for students in all years of Metallurgy and Materials Science and in the Third and Fourth Years of the Materials Science option of Engineering Science. Bursaries are awarded on the basis of academic ability and the need for financial assistance. Applications should be made to the Secretary not later than October 1. The first award was made for the Session 1958–59.

ONTARIO CHAPTER, AMERICAN SOCIETY FOR METALS SCHOLARSHIP

The Ontario Chapter provides one scholarship of a value of $250 for academic excellence to be awarded to a student in Metallurgy and Materials Science after completion of the Second or Third Year, or the Materials Science option of Engineering Science (Third Year). The first award was based upon the results of examinations in the Session 1970–71.

ARDAGH SCHOLARSHIP

The Ardagh Scholarship, of the annual value of the income from $7,500, has been provided in memory of his parents by Professor E. G. R. Ardagh, B.A.Sc., F.R.S.C., formerly professor of Applied Chemistry in the Faculty. It is awarded to the student who attains the highest standing with Honours at the annual examination of the Second Year in the Course in Chemical Engineering. The first award was made on the results of the annual examination of 1946.

ATA TRUCKING INDUSTRY EDUCATIONAL FOUNDATION BURSARIES

The Automotive Transport Association of Ontario has established a bursary fund for students in the second or higher years of any undergraduate degree course who find themselves in serious financial need due to sudden, unexpected personal or family difficulties. Applications may be submitted to the Office of Student Awards at any time during the session and the number and value of the bursaries will vary at the discretion of the Committee of Award.

THE BABB BURSARY FUND

Bursaries from this fund are available to students in any year of the Aeronautics Option in Engineering Science. Application is made through the Secretary of the Faculty.

THE F. W. BALDWIN PRIZE

The F. W. Baldwin Prize of a value of $75 was established by the trustees of a fund created by the members of Number 3 Squadron, University Air Training Corps (1941–44), in memory of Frederick Walker "Casey" Baldwin, a graduate of the School of Practical Science, who made a significant contribution in the field of Aeronautics in Canada; and who flew, on March 12, 1908, near Hammondsport, N.Y., the "Redwing," the first biplane built by the Aerial Experiment Association.

It is awarded annually to the student registered in Third Year, Aeronautics Option, in Engineering Science, who, taking honours, ranks highest in the annual examinations of Third Year in "structural subjects."

The first award was made on the results of the examinations of the Session 1953–54.

BAPTIE SCHOLARSHIP

The Baptie Scholarship is derived from a bequest under the will of the late Mrs. Margaret W. Baptie, of Ottawa, and the Board of Governors has directed that a scholarship of one half the annual income shall be awarded annually to an engineering student on the record of the First Year. The Board of Governors also authorizes a remission of fees in the case of the holder of the scholarship, up to $75.

The conditions of the award are as follows: That the scholarship be awarded to the student who, in the annual examinations of the First Year, enrolled in any of the courses of Civil Engineering, Mechanical Engineering, Chemical Engineering, Electrical Engineering, or Metallurgy and Materials Science, obtains the highest aggregate percentage of marks in those subjects which are common to the First Year curricula of those courses. The first award was made on the results of the annual examinations of the Session 1925–26.

CANADIAN BECHTEL LIMITED BURSARIES

Canadian Bechtel Limited has established Bursaries in the Faculty of Applied Science and Engineering of an annual value of $1,200 to provide two or more awards, each of a minimum value of $150. One award will be made to a First Year student and the remaining awards may go to students registered in any year of the Faculty. Applicants must demonstrate financial need and have academic standing satisfactory of the Faculty Council.

Application must be made to the Secretary of the Faculty on or before October 1.

J. P. BICKELL FOUNDATION SCHOLARSHIPS

The Trustees of the J. P. Bickell Foundation have established scholarships, the number to be determined annually, in the Faculty of Applied Science and Engineering of a possible value of $1,500 payable $500 in the First Year and provided honours are obtained at the annual Examinations, $500 in the Second and Third Years.

An applicant must obtain an average of at least 75% at the Ontario Grade XIII examinations immediately preceding his admission to the University and must undertake to enroll in Chemical Engineering, Metallurgy and Materials Science or Geological Engineering. Failing suitable candidates in the courses mentioned, students registered in the Second Year Honour course in Geological Sciences, or Physics and Geology in the Faculty of Arts and Science who are academically qualified are eligible. These awards are of the same value and are tenable in the Second, Third and Fourth Years of the course, subject to maintenance of the required academic standing. If any scholarships are not awarded to those mentioned above, students registered in the Third Year of the Engineering Science course in the Faculty of Applied Science and Engineering and taking the Physical Metallurgy or the Geophysics option who are academically qualified are eligible. In this case the scholarship will have a value of $1,000, payable $500 in each of the Third and Fourth Years, provided the required academic standing is maintained.

Applications from those entering First Year must be submitted to the Office of Student Awards not later than May 1 on the regular admission scholarship application form. In other cases, applications are not required.

J. P. BICKELL FOUNDATION BURSARIES

The Trustees of the J. P. Bickell Foundation have established the J. P. Bickell Foundation Bursaries in the Faculty of Arts and the Faculty of Applied Science and Engineering. An applicant must be enrolled in Honour Science or in Mathematics, Physics and Chemistry in the Faculty of Arts, in which case he must undertake to study mining or geology in his higher years; or be enrolled in a higher year of an honour course in the geological or geophysical field in the Faculty of Arts; or be enrolled in Chemical Engineering, Mining Engineering, Metallurgy and Materials Science, or Geological Engineering in any year of the Faculty of Applied Science and Engineering. He must demonstrate financial need and have satisfactory academic standing.

Application must be made to the Office of Student Awards on or before November 15.

THE T. H. BICKLE PRIZE

The T. H. Bickle Prize is the gift of Mr. and Mrs. E. W. Bickle in memory of their son, T. H. Bickle, an undergraduate of Trinity College and a member of the Senior Intercollegiate Swimming Team at the time of death in 1937. The income from the endowment fund will be used to purchase a suitable prize to be awarded annually to a member of the Senior Intercollegiate Swimming Team of this University in any year, faculty or school. The Committee of Award shall consist of the Dean of the Faculty of Arts, the Director of Athletics, and the Honorary Coach of Swimming. In awarding the Prize the Committee shall consider the character, scholarship, and general interests of the members of the team.

J. W. BILLES ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of J. W. Billes, open to students entering any degree course in the University. The value in each year is a minimum of $250 and a maximum of $1,500 dependent upon the financial need of the recipient. Applicants must satisfy the normal admission scholarship standards in their Grade XIII examinations to be eligible for an award and maintain first class honour standing to enjoy the scholarship in higher years. The number of scholarships awarded in any one year may be varied dependent upon the available funds.

Application should be made to the Office of Student Awards by April 19 on the regular admission scholarship application form.

CANADA STUDENT LOANS PLAN

Full details of this Plan are available in a brochure issued each spring by the Government of Canada. Basically, the plan is designed for those students who have resided in Canada for twelve months and demonstrate financial need, but who do not qualify for assistance under the Ontario Student Assistance Program. Effective 1972, the maximum Canada Student Loan is $1,400 per academic year. The application form for the Ontario Student Assistance Program is also used for the Canada Student Loans Plan.

Application forms and brochures are available from the University of Toronto, Office of Student Awards, and all other post-secondary institutions, and should be submitted to the institution which the student plans to attend.

Students who intend to study outside Ontario or abroad should apply through the Ministry of Colleges and Universities, Mowat Block, Queen's Park, Toronto, Ontario.

CARVETH METALLURGICAL LTD. BURSARY

Carveth Metallurgical Ltd. provides one or more bursaries to a total value of $500 for students entering the Third Year of Metallurgy and Materials Science. The award is made primarily on the basis of Second Year standing, but the need for financial assistance will also be taken into consideration.

The Bursary is available every third year, beginning in the Session 1961–62, and is to be awarded on the recommendation of the Department of Metallurgy and Materials Science. Application should be made by letter to the Secretary of the Faculty of Applied Science not later than September 1 of the year in which the award is tenable.

CENTENNIAL THESIS AWARDS

In honour of the Centennial of the Faculty in 1973, the Dean has provided funds to set up awards which recognize outstanding Fourth Year thesis work. In 1972–73 each award had a value of $50 and they were made to students in each of the Faculty's eight degree programs. The selections are made on the recommendation of thesis coordinators in the various departments.

CHEMICAL INSTITUTE OF CANADA PRIZE

The Chemical Institute of Canada offers a prize of the annual value of $25 in books to the student registered in the course in Chemical Engineering who, having obtained honours, receives the highest standing in the written and laboratory work of the Third Year.

The first award was made on the results of the final examinations of 1947.

CHEVRON STANDARD LIMITED SCHOLARSHIP

Chevron Standard Limited has presented a scholarship of $500 to a student who achieves outstanding results in the annual examinations of the Third Year in the Geophysics

Option in Engineering Science or in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and Science.

The awards alternate annually between the Faculties of Applied Science and Engineering (even years) and Arts and Science (odd years). The First Award was made in the session 1960–61 in the Faculty of Applied Science and Engineering.

CHILDREN OF WAR DEAD (EDUCATION ASSISTANCE) ACT

Children of War Dead (Education Assistance) Act provides fees and monthly allowances for children of veterans whose death was attributable to military service. Enquiries should be directed to the nearest District Office of the Department of Veterans Affairs.

5T6 CIVILS SCHOLARSHIPS

The 5T6 Civils, consisting of the graduating members of the 1956 Civil Engineering Class of the University of Toronto, have established an annual scholarship of the value of $200 open to students who have completed the Second Year of the course in Civil Engineering and are registered in the Third Year of the course. The selection of the recipient is based on evidence of the qualities of scholarship, leadership and character. The award is not tenable with any other scholarship of greater value.

The award is presented at the annual reunion of the Class of 5T6 Civils. The first award was made in 1964.

Students who wish to be considered for this scholarship should write to the Class of 5T6 Civil Engineering, c/o Alumni House, University of Toronto, not later than December 31, giving full particulars of their academic record, and their extra-curricular activities both within and outside the University.

COMINCO SCHOLARSHIPS

Two scholarships, of an annual value of $800 each, are provided by Cominco Limited and are offered to students in the Third Year of the courses in Chemical Engineering, Geological Engineering, Mechanical Engineering and Metallurgy and Materials Science in the Faculty of Applied Science and Engineering and to students in the Third Year of the courses in Chemistry and Geology in the Faculty of Arts and Science. The scholarships may be renewed in the Fourth Year if satisfactory standing is maintained.

Application must be made to the Secretary of the Faculty on the regular in-course awards form not later than October 15.

SYDNEY C. COOPER BURSARIES

An amount of $900 is provided annually for bursaries to be awarded to students in the

Third and Fourth Years of the program in Civil Engineering who have achieved at least second-class standing in the previous year and who are in need of financial assistance.

Application must be made on the regular in-course bursary application form not later than November 15.

CROCKER FOUNDATION BURSARIES

The income from a capital fund established from the estate of the late Beatrice Crocker Glazier in memory of her brother, James William Crocker, provides bursaries for students in the Faculty of Medicine and the Faculty of Applied Science and Engineering who are in need and are worthy of financial assistance.

Application should be made to the Secretary of the Faculty not later than November 15.

THE CULLITON SCHOLARSHIP

Mr. Peter J. Culliton, B.A.SC., 2T1, M.A.SC., 2T3 (Civil Engineering), has graciously donated a sum of $1500 to the Faculty to be used to fund this award. The scholarship, first awarded in 1973–74 will have a value of $300 annually until 1978–79, when the fund will have depreciated and a smaller final award will be made. The scholarship is awarded to the student in Civil Engineering who achieves the highest standing at the annual examinations of the Third Year among those who do not hold an award of higher value.

CYANAMID OF CANADA SCHOLARSHIP

As a part of their program to encourage technical development in Canada, Cyanamid of Canada Limited offers a scholarship of the value of $750 to a student entering the Third Year in Chemical Engineering or Industrial Engineering. The award is made to a student who has demonstrated high academic ability and outstanding scholarship in the work of the Second Year.

The first award at the University of Toronto was made in 1964.

DOW CHEMICAL OF CANADA LIMITED AWARD

Dow Chemical of Canada Limited has provided funds for an annual award of $500 to a student in Chemical Engineering in the Faculty of Applied Science and Engineering, and a grant-in-aid of $250 to be used in the winner's department to help defray the cost of equipment, supplies and administration.

The winner must:

(*a*) be registered in the Third Year in Chemical Engineering (the award will be made in the second term of the Third Year and will be paid to the winner during his Fourth Year);
(*b*) be in the upper half of the class;
(*c*) have demonstrated leadership in extra-curricular activities.

The award is not tenable with other awards in the gift of the Governing Council. Application is not required.

THE ELECTRICAL MANUFACTURING COMPANY LTD. – MONTEL INC. PRIZE

The Electrical Manufacturing Company Limited has established an annual Prize of $50 in the Faculty of Applied Science and Engineering.

The winner must:
(*a*) be registered in the Fourth Year in Electrical Engineering;
(*b*) obtain the highest aggregate percentage of marks at the final examinations in the subjects of the Fourth Year related to electrical distribution equipment, the subject to be determined by the Head of the Department of Electrical Engineering.

This Prize is tenable with other awards in the gift of the Governing Council.

THE JOHN M. EMPEY SCHOLARSHIPS

The John M. Empey Scholarship Fund was established under a bequest of $10,000 in the Will of the late John Morgan Empey, B.A.Sc., 1903. Three scholarships of equal value are provided from the income from the Fund. One of these scholarships is awarded in each of the First, Second, and Third Years on the results of the annual examinations, to a student who, taking honours, obtains the highest average percentage of marks in the written and laboratory subjects of his Year. The scholarships are open to any students registered in the Faculty. In case the winner of any one of these scholarships does not attend this Faculty during the session next following the award, the right to the scholarship shall be forfeited and the awards shall be made to another eligible student. The scholarships were awarded for the first time in 1944.

ENGINEERING ALUMNI CENTENNIAL ADMISSION SCHOLARSHIPS

Seven scholarships, each of the value of $1000, are provided annually by the University of Toronto Engineering Alumni Association for students entering the First Year of any course in the Faculty of Applied Science and Engineering. The awards are made on the basis of standing in the Ontario Grade XIII examinations.

Application should be made to the Office of Student Awards by April 19 on the regular admission scholarship application form.

ENGINEERING ALUMNI CENTENNIAL BURSARIES

Thanks to the generosity of the Engineering Alumni Association, a number of bursaries have been established in the Faculty of Applied Science and Engineering. These bursaries are awarded on the basis of academic achievement and financial need, with preference being given to students in the Third and Fourth Years.

Application should be made to the Secretary of the Faculty not later than November 15.

ENGINEERING INSTITUTE OF CANADA PRIZE

The Engineering Institute of Canada Prize, of the value of $100, is awarded annually to a Student Member of the Institute on the basis of the marks made at the completion of his penultimate year of undergraduate study, and on his activities in the Engineering Society or in the student branch of a recognized engineering Institute or similar organization.

ENGINEERING SOCIETY CENTENNIAL AWARD

The Engineering Society Centennial Award, to the value of $100, was established in 1973 to commemorate the Centennial of the founding of the School of Practical Science. The award is made to a student entering the Second or Third Years.

The selection is based on the following qualifications, which each bear equal weight in the selection of the winner: (*a*) General "Skule" activities; (*b*) Contributions to the Engineering Society Council; (*c*) Personality, and social and athletic activities. The winner must obtain an unconditional pass standing on the work of the year.

ENGINEERING SOCIETY SEMI-CENTENNIAL AWARD

The Engineering Society Semi-Centennial Award, currently having a value of $100, was established in 1931 to commemorate the first graduating class of the School of Practical Science. The award is made to a student entering the final year.

The selection is based upon the following qualifications, which bear equal weight in the selection of the winner: (*a*) General "Skule" activities; (*b*) Contributions to the Engineering Society Executive Committee; (*c*) Personality, and social and athletic activities; (*d*) Academic Standing.

J. A. FINDLEY SCHOLARSHIPS

These scholarships were established through a legacy bequeathed by the late Miss Janet Findlay to the Department of Mechanical Engineering. Two scholarships are available, each of a value of one half of the income of the fund, to students in this Course, one for a student in the Third Year, the other for a student in the Fourth Year, but only if the student continues his course in Mechanical Engineering. The selection will be made, on recommendation of the Head of the Department of Mechanical Engineering, from amongst the four students having the highest average percentage of marks at the annual examinations in the Second and Third years respectively, but in making the award the student's general character, fitness for his profession, and financial circumstances will be given consideration. In case a student who has been awarded one of the scholarships changes his course or does not attend this University during the next following session, he shall forfeit his right to the scholarship and the award shall be made to another eligible student.

THE JAMES FRANCESCHINI FOUNDATION SCHOLARSHIP

This scholarship, of a value of $300, is awarded to the student in Civil Engineering who achieves the highest standing, with honours, at the annual examinations of the Third Year among those who do not hold an award of a value of $100 or more based on the results of these examinations.

HUGH GALL AWARD

The Hugh Gall Award was established in 1946 by the Graduate Class of 1910 "to commemorate a deceased classmate who was a splendid type of student, a loyal friend, and nationally outstanding in athletic achievement during his undergraduate career." Upon expiration of the original gift in 1951 the award was supported by Mrs. Hugh Gall until her death in 1970; under the terms of her will a sum of $5,000 was provided to support the award in perpetuity, the annual value of the award being the income from the bequest. The award is made to a student who, having completed his First Year with a general average of at least 66% without conditions, has entered the Second Year, and is in special need of financial assistance in order to enable him to continue his course. It is desirable, but not necessary, that the recipient shall not already have been given any other scholastic award or scholarship applicable to the Second Year and he shall have shown indications of his firm intention and ability to follow successfully the profession of engineering.

Any Second Year student in the Faculty of Applied Science and Engineering is eligible to apply for this Bursary. Applications should be made to the Secretary of the Faculty not later than November 15.

THE GENERAL MOTORS SCHOLARSHIPS

General Motors of Canada Limited has established two scholarships in the Faculty of Applied Science and Engineering which were first awarded in 1973–74. Each year the scholarships, having an annual value of $1000, are awarded to the student entering the Third Year and to the student entering the Fourth Year of Mechanical Engineering, who being a Canadian citizen, has demonstrated the highest academic and leadership qualities The scholarship is renewable for one year for the Third Year recipient provided that the student has maintained a satisfactory academic standing. Another General Motors Scholarship is awarded annually in the Faculty of Arts and Science, and accompanying these awards the University receives in addition, a grant-in-aid of $2000 annually.

THE GRABILL ADMISSION SCHOLARSHIP

The Grabill Admission Scholarship is the gift of Mr. Dayton L. Grabill, a graduate of this Faculty in 1924. The Scholarship has a value of approximately $500. It is awarded to the candidate who has standing amongst those with the highest average percentages in the subjects of Ontario Grade XIII required for admission to the Faculty of Applied Science and Engineering. The candidate must write the Grade XIII examinations at one sitting in the June preceding entry to the University after not more than one year's instruction in Grade XIII and must register in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards on the regular Admission Scholarship form by April 19.

THE REGINALD AND GALER HAGARTY SCHOLARSHIP

The Reginald and Galer Hagarty Scholarship was first awarded in 1945 in memory of the sons of Lieutenant-Colonel E. W. Hagarty and Charlotte Ellen Hagarty, his wife. It has the value of the annual interest on the capital sum of $2,000 and is awarded to a student who has completed Grade XIII at Harbord Collegiate Institute. Further details are available from, and application should be made to, the Office of Student Awards before April 19.

THE GEORGE A. GUESS SCHOLARSHIPS

The estate of Edna F. Guess, wife of George A. Guess, formerly Head of the Department of Metallurgical Engineering, has bequeathed funds to the University for the purpose of establishing the George A. Guess Memorial Fund for the assistance of needy students of Metallurgy. The annual income of the Fund is used to provide graduate fellowships, summer studentships and an undergraduate fund in the Department of Metallurgy and Materials Science in addition to the George A. Guess Scholarships.

A maximum of six George A. Guess Scholarships may be awarded annually, each having a value equal to the total annual registration fees. The scholarships are awarded only to needy students whose year averages are 80% or better and who do not hold another academic award.

Three awards are made to students entering the Second, Third or Fourth Years of Metallurgy and Materials Science, two awards to students entering the Third or Fourth Years of the Materials Science Option of Engineering Science and one award to students entering the Third or Fourth Years of the Mineral Engineering Option of Geological Engineering. If there are insufficient numbers of qualified students in any of the eligible programs, then the remaining awards may be distributed to qualified students in either of the other two programs. If six awards are not made in any year, the residual sum will remain in the George A. Guess Fund to be used for one of the purposes stated above. The first awards will be made on the results of the examinations of 1974–75.

CHESTER B. HAMILTON SCHOLARSHIP

Members of the family of the late Chester B. Hamilton, a graduate of the Faculty in 1906, have presented a Scholarship in his memory of the annual value of $500. It is held by a Fourth Year student in Mechanical Engineering who has achieved outstanding academic standing at the Annual Examinations of the Third Year.

The first award was made on the results of the examinations for the Session 1958–59.

THE MURRAY CALDER HENDRY SCHOLARSHIP

This award was established by the estate of Mrs. Grace Appel Hendry as a memorial to her husband, a graduate of this Faculty in 1905. It has a value of the income from a capital sum of $10,000 and the recipient must:

(*a*) have attained an average of at least 75% on the grade XIII examination papers, written at one sitting, required for admission to the Faculty.

(*b*) be entering the First Year of any course in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards by May 1 on the regular University Admission Scholarship Application form.

The first award was made in the Session 1962–63.

ROY JARVIS HENRY ADMISSION SCHOLARSHIPS

The estate of the late Roy Jarvis Henry provides three scholarships of the value of $500 each, to be awarded to students who have achieved high standing on the Ontario Secondary School qualifications required for admission, two of which are open to students entering any course in the Faculty and one open to students entering Geological Engineering. In the lack of a suitable candidate in Geological Engineering, all three awards are tenable in any course in the Faculty. Application must be made on the regular admission scholarship application form.

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO BURSARY

The Hydro-Electric Power Commission of Ontario has provided a bursary of the value of $500, which may be awarded to a student entering the Second Year of the courses in Mathematics and Physics of Commerce and Finance in the Faculty of Arts and Science, or any course in the Faculty of Applied Science and Engineering. Application should be made on the regular in-course bursary form not later than November 15.

IBM-THOMAS J. WATSON MEMORIAL BURSARY FUND

International Business Machines Company Limited has made available one or more bursaries of a total annual value of $1,000 to students registered in any year of a full time course in the University who have standing satisfactory to the Committee of Award and demonstrate financial need.

Application should be made to the Office of Student Awards by November 15.

JENKINS SCHOLARSHIP

The Jenkins Scholarship, presented by Jenkins Bros., Limited, Montreal, first awarded in 1925, has been donated to continue indefinitely.

This Annual Scholarship, of the value of $200, is awarded to the student of the Third Year registered in any course of the Faculty who has the highest aggregate of percentages for the First, Second and Third Years.

JOHNSON'S WAX SCHOLARSHIP

S. C. Johnson and Son Limited, Brantford, Ontario, have established a Scholarship of an annual value of $800 in each of the Second, Third and Fourth Years or a total possible value of $2,400.

The recipient must:

(*a*) be registered in Chemical Engineering in the years in which the Scholarship is awarded and held;

(*b*) in the opinion of the Council be the most promising and deserving member of the class, obtaining Honours in the final examinations of the First Year;

(*c*) in his Second and Third Years, maintain academic standing satisfactory to the Council, not necessarily Honours, for the continued enjoyment of the Scholarship. In its discretion the Council may recommend the award of any portion of the Scholarship lost by the original recipient by failure to maintain satisfactory academic standing, to another student of the year(s) in which the Scholarship would otherwise have been enjoyed.

The first award was made on the results of the annual examinations written in April 1954. It is not tenable with any other Scholarship.

J. EDGAR McALLISTER FOUNDATION BURSARIES

Through the generosity of the late J. Edgar McAllister, a graduate of the Faculty in 1895, a fund has been established in the University to be known as the J. Edgar McAllister Foundation, to provide financial aid for students who require it, in Mechanical, Chemical, Electrical and Geological Engineering and Metallurgy and Materials Science. Application should be made on the regular in-course bursary form not later than November 15.

J. EDGAR McALLISTER FOUNDATION ADMISSION AWARDS

Provided for by the bequest of the late J. Edgar McAllister, B.A.Sc., twenty-five awards of the value of $1,000 each are available to students entering the First Year of the programs in Mechanical, Chemical, Electrical and Geological Engineering and Metallurgy and Materials Science, who have achieved high standing in the secondary school courses prescribed for admission and who are in need of financial assistance.

Applicants wishing to be considered for these awards should complete the financial need section on the regular University of Toronto Scholarship Application form, which is to be submitted not later than April 19.

J. EDGAR McALLISTER FOUNDATION UNDERGRADUATE AWARDS

Provided for by the bequest of the late J. Edgar McAllister, B.A.Sc., five awards of $1,000.00 each are available to students entering the Second Year in Chemical, Electrical, Geological and Mechanical Engineering, and Metallurgy and Materials Science, who have achieved honours standing in the work of the preceding year. Normally one award will be made in each of the eligible programs, but in the absence of a suitable candidate in a particular program, two awards may be made in another. The bequest also provides for five awards to students entering Third Year, and five to students entering the Fourth Year of Chemical Engineering or the Chemical Option of Engineering Science; Electrical Engineering or the Electrical Option of Engineering Science; Geological Engineering or the Geophysics Option of Engineering Science; Mechanical Engineering or the Nuclear and Thermal Power Option of Engineering Science; and Metallurgy and Materials Science or the Materials Science Option of Engineering Science.

These awards are not tenable with any other scholarships.

THE J. A. D. McCURDY PRIZE

The J. A. D. McCurdy Prize of a value of $75 was established by the trustees of a fund created by the members of the Number 3 Squadron, University Air Training Corps (1941–44) in honour of John Alexander Douglas McCurdy, a graduate of the School of Practical Science, who "made the first flight in Canada on February 23, 1909, with a heavier-than-air machine."

It is awarded annually to the student registered in Third Year, Aeronautics Option, in Engineering Science, who, taking honours, ranks highest in annual examinations of the Third Year in the subjects related to Aerodynamics.

The first award was made on the results of the examinations of the Session 1953–54.

THE GARNET W. McKEE-LACHLAN GILCHRIST SCHOLARSHIP IN ENGINEERING SCIENCE

Mrs. Garnet W. McKee and Professor Lachlan Gilchrist each contributed $1,00 to provide for a Scholarship in the First Year of the course in Engineering Science.

The value of the Scholarship is the annual income from the capital fund and is awarde to the student who ranks first in honours at the annual examinations of the First Year in the course in Engineering Science. If for any reason that student is ineligible to hold the Scholarship, it will be awarded by reversion to the student ranking second in honours in the course. In order to receive payment the winner must register in the Second Year of the course in Engineering Science. The Scholarship was awarded for the first time on the results of the annual examinations of 1947.

THE GARNET W. McKEE-LACHLAN GILCHRIST GEOPHYSICS SCHOLARSHIPS

Financial assistance was received by Professor Lachlan Gilchrist of the Department of Physics, University of Toronto, from certain organizations and individuals to help him in the prosecution of his research work in Geophysics. With the consent of the contributors, the unexpended balance of these gifts was transferred by Professor Gilchrist to the Board of Governors of the University to be used as an endowment for scholarships, two of which were established in the Faculty of Applied Science and Engineering. To this fund have been added additional amounts received from the estate of the late Garnet W. McKee and from the Hollinger Consolidated Gold Mines Ltd. They are awarded by the Governing Council, on the recommendation of the Council of the Faculty of Applied Science and Engineering. The first awards were made on the results of the Annual Examinations of 1941.

The First Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $200 is awarded to the student in the Second Year in the course of Engineering Science who obtains the highest aggregate standing at the examinations of the First and Second Years in the course, provided always that the student obtains honour standing at the examinations of the Second Year.

The Second Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $165 is awarded to the student in the Second Year in the course of Engineering Science who, of those students who elect to proceed in the Third Year in the Geophysics Option of the course, obtains the highest aggregate standing at the examinations of the First and Second Years, provided always that the student obtains honour standing at the examinations of the Second Year, and excluding always the student to whom the First Lachlan Gilchrist Geophysics Scholarship has been awarded.

If in any year there is no student who has fufilled the condition as laid down for the Second Lachlan Gilchrist Geophysics Scholarship, it shall be awarded to the student in the Second Year in the course in Engineering Science who obtains the second highest aggregate standing at the examinations of the First and Second Years of that course, provided always that such student obtains honour standing in the examinations of the Second Year.

LACHLAN DALES McKELLAR ADMISSION SCHOLARSHIPS

Provided by a bequest of the late Leona D. McKellar, two scholarships of the value of

$500 each, are offered to students who have achieved high standing on the Ontario Secondary School qualifications required for admission to the Faculty. Application must be made on the regular admission scholarship application form.

THE ALEXANDER MACLEAN SCHOLARSHIP

This scholarship was established by graduates of the University of Toronto and other friends in honour of Professor Alexander MacLean, B.A. (1908) who retired in 1954. The scholarship, of the value of $250, is awarded to a student in the Third Year of Geological Sciences, Faculty of Arts, or in the Third Year of Geological Engineering, Faculty of Applied Science and Engineering, who, obtaining not less than 75% in the work of the year, obtains the highest standing in the geological subjects common to the two courses.

The first award was made in 1955.

MACLENNAN-MACLEOD MEMORIAL PRIZE

The Graduating Class of 1910 has donated an annual prize, known as "The MacLennan-MacLeod Memorial Prize," in memory of their first Class President, George MacLennan, who was killed in action in France in 1917, and of Doug. MacLeod, their first Secretary, who died in France in 1916 from wounds received in action.

The prize, of the value of $25, is awarded to the First Year student in the Faculty of Applied Science and Engineering who ranks highest in Calculus among those who obtain standing without condition at the annual written examinations; or, in the event of more than one student obtaining equally high rank in Calculus, the award is made to the one of these who also has the highest standing in some other subject common to the competitors, such as Algebra, such subject to be determined by the Council of the Faculty.

An award will not be made in any year in which, in the opinion of the Council, no student obtains a sufficiently high standing in Calculus to merit the award. If in any year no award is made, a second award will be available in the subsequent year.

CHARLES GORDON MANNING PRIZE

The Charles Gordon Manning Prize was established by a bequest under the Will of the late Jennie Manning in the amount of $500, the annual income from which is to be used to buy books for the winner of the Prize.

The recipient must be enrolled in the Second Year of a course offered by the Faculty of Applied Science and Engineering and, in the opinion of the Council, rank second to the student awarded the Harvey Aggett Memorial Scholarship in the considerations specified for the award of that Scholarship, namely, obtaining honours in his final examinations and being one of the first three in his year by his standing at those examinations relative to the pass requirements in his Department and being "adjudged highest of the three in genera student activities and service in the University during his period of attendance."

The first award was made on the results of the annual examinations of 1954.

MASSEY-FERGUSON LIMITED SCHOLARSHIPS

Massey-Ferguson Limited has established two scholarships each of an annual value of $250, to be awarded on the recommendation of the Council of the Faculty of Applied Science and Engineering to students registered in the Fourth Year of the courses in Mechanical Engineering or Industrial Engineering. In making the award academic achievement, financial need, extra-curricular activities and such other factors as may be deemed appropriate will be taken into consideration.

Application should be made to the Secretary of the Faculty not later than November 15.

GEORGE R. MICKLE ADMISSION BURSARIES

Provided for by a bequest of the late George R. Mickle, five bursaries of the value of $1000 each are available to students entering the First Year of courses in the Faculty of Applied Science and Engineering. The awards are made on the basis of the applicant's academic standing in Grade XIII, and his need for financial assistance. Applicants wishing to be considered for these awards should complete the financial need section on the regular University of Toronto admission awards application form.

JAMES L. MORRIS MEMORIAL PRIZE

The James L. Morris Memorial Prize is the gift of Mrs. J. H. Craig and Mr. J. R. Morris, K.C., in memory of their father, James L. Morris, C.E., O.L.S., D.Eng., the first graduate of the School of Practical Science, who died in 1946 after a distinguished career.

Graduating in Civil Engineering in 1881 as the sole member of his class, Dr. Morris engaged in railway work for some time, first as an engineer and than as a contractor. For 43 years he conducted a successful civil engineering practice in Pembroke, Ontario, involving important undertakings in the field of municipal power and bridge work.

This Prize, of the value of the annual income from $3,000, is awarded annually to the student in the Second Year of the Course in Civil Engineering who obtains the highest aggregate percentage at the annual examinations of the First and Second Years of the course, provided always that the student obtains honour standing at the Examinations of the Second Year.

OTTO HOLDEN SCHOLARSHIP

Otto Holden, B.A.Sc., C.E., D.Eng., was a distinguished hydraulic engineer of international reputation. He served Ontario Hydro for 47 years and retired as Chief Engineer in 1960, having been involved in almost all of the major hydro-electric developments in Ontario. On his death, Mr. Holden left a sum of money which was later augmented by his widow, the late Florence Holden, to establish a scholarship in the Faculty of Applied Science and Engineering. This scholarship, which has a value of approximately $900 is awarded to the student who, completing the Fourth Year in Civil Engineering or Mechanical Engineering with Honours, obtains the highest aggregate marks in hydraulic engineering subjects in the Third and Fourth Years of the course. The first award was made in the session 1967–68.

ONTARIO STUDENT ASSISTANCE PROGRAM

All students who are attending eligible post-secondary institutions in Ontario may qualify for assistance under this Program provided that they satisfy the residence requirements as outlined in the Ontario Student Assistance brochure and demonstrate financial need. An award under this Program will be made to the extent of established need in a combination of a non-repayable grant and a Canadian Student Loan. Application forms and brochures for the 1974–75 Program will be available early in May, 1974. They may be obtained from the University of Toronto, Office of Student Awards, and all other post-secondary institutions. Applications should be submitted in person at the institution which the student plans to attend.

THE ONTARIO HOCKEY ASSOCIATION WAR MEMORIAL SCHOLARSHIP

The Ontario Hockey Association War Memorial Scholarship, the gift of the Ontario Hockey Association, is to be awarded annually at the Grade XIII examination to an applicant whose father served overseas with the Canadian Forces in World War I or II.

The value of this scholarship is $100 in cash, with an allowance of the same amount on the tuition fee for each session.

In determining the award of the scholarship, the academic qualifications of the candidate shall be first taken into account, provided always that no candidate shall be eligible for an award who has not met all the conditions required by the University of candidates for admission scholarships generally; but coeteris paribus, the award shall be made to a student who is in proved need of assistance.

The award shall be made by the Governing Council of the University upon the report of a Committee to be appointed, upon which Committee there shall be always one member of the Staff of the University who shall be deemed to be representative of the Association.

Application should be made to the Office of Student Awards on the regular scholarship application form not later than April 19.

PAULIN MEMORIAL SCHOLARSHIP

The Paulin Memorial Scholarship, provided through the generosity of the late Mr. Fred W. Paulin, a graduate of this Faculty in 1907, was established in memory of his brother John Cameron Paulin, a student of this Faculty, who was fatally injured in 1906 during football practice. The scholarship, which has the value of the income from a capital fund of $10,000, approximately $550 annually, is awarded to a student who obtains high standing in the work of the First Year in the Faculty of Applied Science and Engineering.

PROCTER AND GAMBLE BURSARY PLAN

Procter and Gamble Bursaries, the gift of the Procter and Gamble Company of Canada, are awarded annually to students in all years. Applicants must have at least Second Class Honours or better in the final examinations of the preceding year and demonstrate financial need. Applications must be submitted to the Office of Student Awards on or before December 1.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO ADMISSION SCHOLARSHIP

The Ontario Professional Engineers Foundation for Education provides an admission scholarship of the value of $500. It is awarded to the candidate who obtains the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to the Council that his attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other Admission scholarship.

Application must be made to the Office of Student Awards before April 19.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO SCHOLARSHIPS

The Ontario Professional Engineers Foundation for Education offers scholarships of a value of $250 in each of the First, Second and Third Years in the Faculty of Applied Science and Engineering in any course, to the students who, taking Honours, obtain the highest standing in the work of their respective years.

These scholarships will not be awarded to students who hold other scholarships.

PROFESSIONAL ENGINEERS GOLD MEDAL

The Association of Professional Engineers of the Province of Ontario has established in the Faculty of Applied Science and Engineering an award in the form of a gold medal accompanied by a gift of technical books of an approximate value of $50. The award will be made to the student of the final undergraduate year in any course who, taking honours, obtains the highest weighted average percentage in the practical work and written examinations of the year.

RANSOM SCHOLARSHIP IN CHEMICAL ENGINEERING

The Ransom Scholarship in Chemical Engineering is presented by A. C. Ransom, Esq., of Toronto, for the purpose of encouraging and giving financial assistance to students who choose the field of Chemical Engineering. This donation, consisting of $5,000, provides for a perpetual scholarship of an annual amount such as will be derived from the income of this sum. The first award was made on the results of the annual examinations of 1938.

The scholarship will be awarded annually to the student registered in the course in Chemical Engineering who obtains the highest aggregate percentage of marks in the examinations of the First Year. The scholarship will be paid to the winner only if he proceeds to take his Second Year in the course in Chemical Engineering in the University of Toronto.

J. E. REID MEMORIAL PRIZE

This prize, established in 1967 in memory of the late Professor J. E. Reid, is awarded to the student in the Fourth Year of the course in Electrical Engineering who, graduating with honours, achieves the highest aggregate marks in the Fourth Year examinations in the subjects pertaining to electronic communication.

THE RHODES SCHOLARSHIPS

The Rhodes Trustees offer for award in the Province of Ontario two out of ten of the Rhodes Scholarships for Canadians, each of the value of £1,000 and tenable at Oxford University for a period of two years; in certain cases, a third year may be authorized.

Each candidate must be a British subject with at least five years domicile in Canada and be unmarried; he must have passed his nineteenth but not twenty-fifth birthday on October 1 of the year for which he is elected; he must have completed the first year of his course at a Canadian university at the time of application.

A candidate may apply either for the province in which he has his private home o residence, or for the province in which he has taken his university course.

In that section of the will in which he defined the general type of scholar he desired, Mr Rhodes mentioned four groups of qualities, the first of which he considered most important.

(1) Literary and scholastic attainments;
(2) Qualities of manhood, truth, courage, devotion to duty, sympathy, kindliness unselfishness, and fellowship;
(3) Exhibition of moral force of character and of instincts to lead and to take an interes in his fellows;
(4) Physical vigour, as shown by fondness for and success in outdoor sports.

Some definite quality of distinction, whether in intellect, character or personality, or i any combination of these, is the most important requirement. Financial need does no receive special consideration.

Forms of applications and full information regarding these scholarships may be obtained from the Director, Office of Student Awards, University of Toronto, or from Arthur R. A. Scace, Esq., General Secretary for the Rhodes Scholarships in Canada, Box 48, Toronto Dominion Centre, Toronto 1. Selection is made in December for the following year and all applications must reach the provincial secretary before November 15 annually.

R. C. E. MEMORIAL SCHOLARSHIP

The Memorial Fund Committee of the Royal Canadian Engineers has established the R.C.E. Memorial Scholarship of a value of $125, open to students who have successfully completed their second to last year in the Faculty of Applied Science and Engineering or the School of Architecture.

A Candidate must be:

(*a*) a member in good standing of the Canadian Officers Training Corps and have successfully completed one summer season's training, or

(*b*) an ex-member of the Canadian Officers Training Corps who has successfully completed two years of C.O.T.C. Training and has transferred to the Canadian Army (Militia) or to the Canadian Army (Supplemental Reserve), or

(*c*) a member of the Canadian Army (Regular) attending University under the Regular Officers Training Plan.

Selection is made on the basis of academic standing and of qualities of leadership.

Application forms may be obtained from the Office of Student Awards.

REGULAR OFFICER TRAINING PLAN

Tenable in approved degree courses, this plan is available to Canadian citizens who undertake to serve in the armed forces for at least four years after graduation. Accepted candidates will receive tuition, a book allowance of $125 and a living allowance of $240 per month during the academic session.

Application should be made to the Canadian Forces Recruiting Centre, 25 St. Clair Avenue West, Toronto.

HELEN E. ROGERS ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of Helen E. Rogers open to students entering any degree course in the University. Preference is given o applicants from outside Ontario but failing such candidates, awards may be made to ualified Ontario students. Recipients must have a standing satisfactory to the Committee of Award on first admission and may continue to enjoy the scholarship in the upper years provided they maintain first class standing. The value in each year is a minimum of $200 and a maximum of $1,500 dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards by April 19 on the regular admission scholarship application form.

DON SALT MEMORIAL SCHOLARSHIPS

In memory of Donald John Salt, a graduate of the Faculty of Applied Science and Engineering and a practising geophysicist, the Canadian Exploration Geophysical Society has provided two scholarships of the value of $500 which are open to students in the Third and Fourth Years of certain courses in the Faculty of Arts and Science, and in Geological Engineering and the Geophysics option of Engineering Science in the Faculty of Applied Science and Engineering.

The award is made on evidence of the interest and ability of the applicant in relation to the field of mining geophysics.

Application should be made either to the Chairman of the Department of Physics or the Chairman of the Department of Geology and Applied Earth Science by March 1 in the calendar year in which the award is to be made.

ROSEDALE CHAPTER I.O.D.E. AWARD IN ENGINEERING SCIENCE

An award of $400 will be made annually to a student enrolled in the Third Year of the program in Engineering Science, on the basis of academic standing and financial need. Recipients must be Canadian citizens, but not necessarily residents of Ontario.

Application should be made to the Secretary of the Faculty on the regular in-cours bursary application form not later than November 15.

FREDERICK W. SCHUMACHER SCHOLARSHIP

The Frederick W. Schumacher Scholarship has been awarded in the Faculty of Applie Science and Engineering and in the Faculty of Arts under a bequest of the late Frederick W. Schumacher. It has a value of the income from the fund. The scholar must (*a*) be enrolled in the Second, Third or Fourth Years in Geological Engineering in the Faculty o Applied Science and Engineering or in Physics and Geology or Geological Sciences in th Faculty of Arts and (*b*) must have high academic standing.

Applications must be submitted to the Office of Student Awards not later tha November 15.

"SECOND MILE ENGINEER" AWARD

The Class of 3T5, convinced that a successful engineer must not only be professionall competent but also constantly aware of his responsibilities to humanity, and inspired by an address of President William E. Wickenden of the Case School of Applied Science, Cleveland, called ''The Second Mile,'' which was based on the text from the Sermon on the Mount, ''whosoever shall compel thee to go one mile, go with him twain'', has established the ''Second Mile Engineer'' award. It is the desire of the donors to encourage undergraduates to participate fully in extra-curricular activities and to recognize the true importance of the more liberal subjects of the curriculum with the ultimate objective, on entering the profession, of becoming worthy Second Mile Engineers. The award comprises a grant of $200, a suitably inscribed presentation piece and an illuminated scroll, and is presented to a student in his final year.

An eligible group is chosen from those who have taken a prominent part in the affairs of the Faculty, either as office holders or in athletics. In making the award, consideration is given to academic standing, with special emphasis on the candidate's attainments in the cultural and humanistic-social studies.

Particulars are furnished each session by the Class of 1935.

THE SIMPSONS-SEARS LIMITED (NORTHERN ONTARIO) SCHOLARSHIPS

These scholarships, the gift of Simpsons-Sears Limited, are open only to students of the Copper Cliff High School, the Sudbury High and Technical Schools, the Sturgeon Falls High School, the North Bay Collegiate Institute and Vocational School, the Kapuskasing High School and all the Secondary Schools along the Ontario Northland Railway. A scholarship of the value of $100 is available for each of the schools mentioned and an additional sum of $50 will be given to the student who obtains the highest percentage of Grade XIII subjects selected in accordance with the regulations.

No scholarship will be awarded unless the candidate is in actual attendance in one of the colleges or faculties of the University and maintains a uniformly high standard to the satisfaction of the donors of the scholarships.

Application for these scholarships must be sent not later than May 15, to the Principal, Algonquin Composite School, North Bay, from whom further information may be obtained regarding conditions of award.

WALLACE AWARD
SOCIETY OF AUTOMOTIVE ENGINEERS PRIZE

In memory of William Wallace, Professor of Mechanical Engineering, University of Toronto , the Ontario Society of Automotive Engineers offers an annual prize of the value of $100 to a student of the Fourth Year in any course whose thesis on a topic related to Automotive Engineering is considered by the Chairman of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory.

SOCIETY OF CHEMICAL INDUSTRY MERIT AWARD

The Society of Chemical Industry Merit Award is made annually by the Society to the student in Fourth Year in the Department of Chemical Engineering who obtains the highest weighted average of marks in the results of the annual examinations for the year. The award is a gold key.

THE MURRAY F. SOUTHCOTE SCHOLARSHIP

Established by friends of the late Murray F. Southcote, a graduate of this Faculty (Aeronautical Engineering, 1950) this scholarship, which has a value of $100, is awarded in recognition of high standing at the Annual Examinations of the Third Year, in any course in the Faculty.

The first award was made in the Session 1964–65.

WALTER STERLING ADMISSION SCHOLARSHIPS

Established in memory of Walter Sterling, these scholarships are open to students entering any first degree course at the University of Toronto. Recipients must obtain First Class Honours standing on the Ontario Grade XIII papers required for admission and may continue to enjoy the scholarships in each year of their course providing they maintain Honour standing. The value of the scholarship is from $200 to $1,500 annually, dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards on the regular scholarship application form. The statement of financial need should be completed if an award greater than $200 is desired.

C. H. E. STEWART BURSARIES

Under the provisions of the will of the late Mary Jones Stewart a sum of $10,000 was bequested to the University, the income of which is to be used to provide a number of bursaries in denominations of $50, $75 and $100 to students in the Third and Fourth Years of courses in the Faculty of Applied Science and Engineering, the awards to be made on the basis of financial need, scholastic ability and general character, with preference being given to students who are descendants of veterans of the First and Second World War. Applications should be submitted to the Secretary of the Faculty by November 15, on the regular in-course bursary application form.

EDITH TYRRELL MEMORIAL BURSARY

The Women's Association of the Mining Industry of Canada has presented this Bursary, having the value of $600, annually, commencing in 1939, and named in memory of their founder and president, Mrs. Edith Tyrrell. A medal donated by Dr. Tyrrell accompanies this Bursary. The Bursary is awarded to a student entering the Third or Fourth Year in the course of Metallurgy and Materials Science, or Geological Engineering; it may be awarded two years in succession to the same student, but will usually be awarded at the beginning of the Third Year. The award will be made by a special Committee appointed by the Association on the following basis:

(*a*) In addition to mental capacity, the student must show leadership ability and give promise, through his activities, of becoming a worthwhile influence in the affairs of the profession and the community.

(*b*) While attention is given to scholastic ability, as evidenced by his academic standing, it is not the governing factor. He must, however, stand in the top quarter of his class.

(*c*) Special consideration is given to financial need.

Application must be made to the Secretary of the Faculty within one month of the opening of the academic year.

S. UBUKATA FUND

The S. Ubukata Fund for Japanese students was established to assist students from Japan proper to pursue a course of study at the University of Toronto. The fund provides grants of varying values on the basis of the information submitted by the applicants who:

(*a*) must be Japanese students from Japan proper;
(*b*) must register in the University of Toronto devoting full time to their studies;
(*c*) are able to satisfy admission requirements regarding English facility;
(*d*) are not holding other financial aid.

UNIVERSITY OF TORONTO ALUMNI ASSOCIATION WAR MEMORIAL SCHOLARSHIPS

Six scholarships are awarded by the University of Toronto Alumni Association to students entering first degree courses at the University of Toronto. The scholarships have a value of $500 annually, and are tenable for two years, providing satisfactory academic standing is maintained. They are awarded for general proficiency in Grade XIII, and in addition to academic performance the Committee of Award will take into consideration the candidate's relationship to active service in the Armed Forces of Canada, need of financial assistance, participation in extra-curricular activities and such other qualifications as may commend themselves to the Committee. One scholarship will be available to a student whose home is not in the Province of Ontario.

Students resident in Ontario may apply on the general admission scholarship form which must be submitted to the Office of Student Awards not later than May 1. Evidence of relationship to active service in the Armed Forces of Canada should be attached. Students resident outside Ontario may obtain the necessary forms from the Office of Student Awards, University of Toronto.

WALLBERG ADMISSION SCHOLARSHIPS

Six admission scholarships, each of a value of $1000 are awarded annually from the income from the Wallberg Bequest on the recommmendation of the Council of the Faculty to the six candidates who obtain the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The Scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to Council that this attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other admission scholarship.

Applications must be submitted to the Office of Student Awards on the prescribed form by April 19.

WALLBERG UNDERGRADUATE SCHOLARSHIPS

These scholarships, four in number, of the value of $500 each, derived from the Wallberg Bequest, are awarded annually: two to students ranking first and second respectively at the annual examinations of the First Year; one to the student ranking first at annual examinations of the Second Year; and one to the student ranking first at the annual examinations of the Third Year.

Any holder of one of these scholarships may not hold other awards listed in the index with an asterisk. The awards were first made on the result of the annual examination of 1947.

THE STEWART WILSON AWARD

This award is available through the generosity of the Engineering Alumni Association. Its value fluctuates to cover the residence fee of New College ($1,056 in 1973–74). The first award was made in 1965–66. It is open to students who, proceeding to the Second Year of any course in the Faculty of Applied Science and Engineering, were resident or non-resident members of New College during their First Year. The award is based upon academic ability, leadership qualities, contribution to New College activities and financial need. The award winner shall reside in the Stewart Wilson House of New College during the academic year of his tenure.

Application should be made to the Registrar of New College by March 31, and announcements regarding a successful candidate will be made by August 1.

W. S. WILSON MEDALS

These medals have been provided in recognition of the service to the Faculty of Applied Science and Engineering of its former Assistant Dean and Secretary, William Stewart Wilson.

A medal will be awarded to the student in each graduating course, who, attaining Honours, achieves the highest standing in the final year of his course.

The first awards were made in the Session 1962–63.

WILLIAM R. WORTHINGTON MEMORIAL SCHOLARSHIP

The William R. Worthington Memorial Scholarship, the gift of Miss Ida R. Worthington, in memory of her brother William R. Worthington, DIPL. (1904), B.A.Sc. (1905), of the value of the income from the fund, is awarded annually to the student of the Second Year in the course in Civil Engineering who ranks highest at the annual examinations of that year.

The first award was made at the examination for the Session 1954–55.

LOAN FUNDS

From the loan funds mentioned below, small loans can be made to students who are in urgent need of assistance. The funds are not large and the loans must accordingly be restricted, both in amount and number, and principally to students in the Third and Fourth Years.

Inquiries for loans from any of the following funds should be made at the Office of the Secretary of the Faculty.

Engineering Society Loan Fund
Elizabeth Speller Memorial Fund
James W. Crocker Memorial Fund
Harry F. Bennett Educational Fund
S. A. E.-Canadian Section Loan Fund
Avro Aircraft Limited Engineering Loan Fund
The William Storrie Memorial Fund
3T6 Engineers Loan Association
4T0 Engineering Loan Fund
The Devonshire Loan Fund
Class of '09 Trust Fund
University of Toronto Alumni Loan Fund
Wallberg Memorial Loan Fund

CLASS OF 1936 LOAN ASSOCIATION

Members of the Class of 1936 have made arrangements to assist students in obtaining loans through regular banking facilities. Information may be obtained from the Secretary of the Faculty.

ENGINEERING SOCIETY LOAN FUND

In 1932 the Engineering Society repaid to the Board of Governors a series of annual grants which, over a period of years, had been made to the Society for special purposes. The Board of Governors, appreciating this action, set aside this sum, to be known as the Engineering Society Loan Fund, to provide loans to students of the Faculty of Applied Science and Engineering. The administration of the fund is carried out by a Committee appointed by the Governing Council. The fund is not large, and only small loans can be made to relatively few students. Further inquiries should be made at the Office of the Secretary of the Faculty.

ELIZABETH SPELLER MEMORIAL FUND

Through the generosity of Dr. F. N. Speller, of the Class of 1893, the "Elizabeth Speller Memorial Fund" has been established to provide loans for worthy students of the Third and Fourth Years of this Faculty. Applications for loans from this Fund should be made to the Secretary of the Faculty.

JAMES W, CROCKER MEMORIAL LOAN FUND

This fund was established by Mrs. William Crocker in memory of her son, James W. Crocker, a graduate in Mining Engineering in 1938, who was killed in an accident in a mine in the same year.

HARRY F. BENNETT EDUCATIONAL FUND

This fund was established by subscription from members of the Engineering Institute of Canada in memory of the late Harry F. Bennett, M.E.I.C., who for six years pior to his death in 1946 was chairman of the Institute's Committee on the Training and Welfare of the Young Engineer, and who accomplished so much in this field by untiring efforts.

One purpose of the fund is to make loans to deserving students who need financial assistance to enable them to study Engineering Science at University level, and who have proved themselves by successfully completing their First Year in Engineering or the equivalent.

Loans will be made largely on the basis of character and to men who seem likely to develop the high professional standards which are essential to leadership in Engineering Science. A student who has been aided by this fund should feel that high obligations are placed on him; obligations to the subscribers, to the trustees, and to those coming after him who in turn can receive help as his loan is repaid.

Application forms may be obtained at the Faculty Office. The regulations are simple and the application of any worthwhile student will be given immediate and careful attention.

SOCIETY OF AUTOMOTIVE ENGINEERS – CANADIAN SECTION LOAN FUND

The Society of Automotive Engineers – Canadian Section has established a loan fund of $1,200 in the Faculty of Applied Science and Engineering. Preference is given to students in good scholastic standing and engaged in studies relative to the automotive and aircraft industries, and to students in Fourth, Third and Second years in that order. Particulars may be obtained from the Secretary of the Faculty.

AVRO AIRCRAFT LIMITED ENGINEERING LOAN FUND

Avro Aircraft has established a loan fund of $3,000 to provide loans to Engineering students requiring financial assistance. Application should be made to the Secretary of the Faculty.

THE WILLIAM STORRIE MEMORIAL FUND

The William Storrie Memorial Fund has been established by Mrs. William Storrie to provide loans to undergraduates in the course in Civil Engineering. Application should be made to the Secretary of the Faculty.

THE DEVONSHIRE LOAN FUND

This fund has been established by Graduates and friends of Devonshire House to assist students in the Residence. Application should be made to the Office of the Dean of Devonshire House.

CLASS OF '09 TRUST FUND

The Class of '09 on the 50th Anniversary of their graduation made a sum of money available in the Faculty for financial aid to undergraduates, with preference to Second Year students. Inquiry should be made to the Secretary of the Faculty.

THE UNIVERSITY OF TORONTO ALUMNI LOAN FUND

This fund comes from subscriptions received originally in 1919 and in succeeding years from graduates of the University and is administered by the University of Toronto Alumni Association.

Loans are available to undergraduate and graduate students enrolled in a full time course at the University, in Second and subsequent years.

Particulars may be obtained from The University of Toronto Alumni Association, Alumni House, Willcocks Street, Toronto.

IX

Discipline

A SUMMARY OF THE REGULATIONS OF THE CAPUT CONCERNING STUDENT DISCIPLINE*

1. Subject to the general regulations of the Caput of the University regarding jurisdiction in matters of discipline the Council of University College, the governing bodies of the Federated Universities and Affiliated Colleges, and the Councils of the Faculties, Schools, and Institutions have disciplinary jurisdiction over the conduct of all students registered in these Divisions of the University in all matters of local or internal concern to these Divisions. Jurisdiction over the conduct of students while in residence regardless of the Division of the University in which they are registered is vested in the body administering the residence.

2. Jurisdiction concerning conduct likely to affect the interests of the University as a whole is vested in the Caput.

3. The Students Administrative Council will be supported in the proper performance of all its obligations and duties as provided in its Constitution.

4. Where the appropriate body exercising disciplinary jurisdiction has found that a student of the University has engaged in conduct prejudicial to the interests of the University, the Caput may, in its discretion, suspend or expel such student from the academic privileges of the University. Every decision of the Caput involving the expulsion of a student from the University requires confirmation of the Governing Council.

5. Any student who interferes with the personal liberty of another or who subjects another student to indignity or personal violence may be considered by the Caput or any other body exercising disciplinary jurisdiction in the University to have committed a breach of discipline.

6. Initiation ceremonies involving physical violence, personal indignity, interference with personal liberty, or destruction of property, may be deemed a breach of discipline by the Caput or any other body exercising disciplinary jurisdiction in the University.

7. Without limiting the disciplinary powers vested in the respective bodies exercising disciplinary jurisdiction as set forth in sections 1–7, the following are cited as illustrations of conduct which, in the past, has been considered a breach of discipline prejudicial to the interests of the University:

(i) The organising of a parade on the streets of the city or the taking part in such a parade without permission of the authorities.

(ii) The destruction or defacing of University property, raids on Residences or other University buildings, and the breaking, into University buildings.

(iii) Rowdy and other forms of behaviour, either on or off the Campus, of such an objectionable nature as to bring the University into public disrepute.

8. Students Clubs and Associations.

(*a*) The constitution of every society or association of students in the University and all amendments to such constitutions require to be approved by the relevant University authorities. The giving of approval, and the responsibility for the programs of student societies and associations, shall rest as follows:

(i) With the authorities of the College, Faculty or School concerned where the member ship of the student society or association is drawn from a single College, Faculty or School.

(ii) With the Board of Stewards of Hart House, where the student society or association is a Committee of Hart House and is controlled by the Board of Stewards of Hart House.

(iii) With the Caput, in the case of all other student societies and associations.

(*b*) No approval will be given by any of the authorities listed in (*a*) above to the constitution of any society or association of students if that constitution permits:

(i) Membership in the society or association to persons who are not students of the University, unless in the case of the societies listed in (*a*) (ii) above, where membership is open also to graduates of the University and members of the Faculty of the University.

(ii) Any action of discrimination based upon race, religion, or colour.

9. The name of the University is not to be used in connection with a publication of any kind without permission of the Caput.

*As of 1972/73. A Committee of the Governing Council began in the fall of 1972 to examine the whole question of non-academic discipline at the University of Toronto, and it may be that a new or significantly amended set of disciplinary structures and principles will be introduced in the session 1974/75. Inquiries should be directed to the College Registrar/Secretary of the Faculty/School or to the Office of the Vice-President-Internal Affairs, Simcoe Hall.

X Professores Emeriti

PROFESSORES EMERITI

E. A. Allcut, M.SC.(BIRM.), M.E., F.R.A.E.S.,
Professor Emeritus of Mechanical Engineering

J. G. Breckenridge, B.A.SC., PH.D.(CAMB.),
Professor Emeritus of Chemical Engineering and Applied Chemistry

W. B. Dunbar, B.A.SC.,
Professor Emeritus of Engineering Drawing

C. E. Helwig, M.A.SC.,
Professor Emeritus of Civil Engineering

P. B. Hughes, B.SC.(McG.), D.ENG.(EMBRY RIDDLE),
Professor Emeritus of Mechanical Engineering

G. K. Korbacher, DIPL.ING.(BERLIN), PH.D.(BRAUNSCHWEIG),
Professor Emeritus of Aerospace Studies

G. R. Lord, B.A.SC., S.M.(M.I.T.), PH.D.,
Professor Emeritus of Mechanical Engineering

O. J. Marshall, B.A.SC., C.E., O.L.S.,
Professor Emeritus of Civil Engineering

W.G.McIntosh, B.A.SC.,
Professor Emeritus of Mechanical Engineering

J. W. Melson, B.A.SC.,
Professor Emeritus of Surveying and Geodesy

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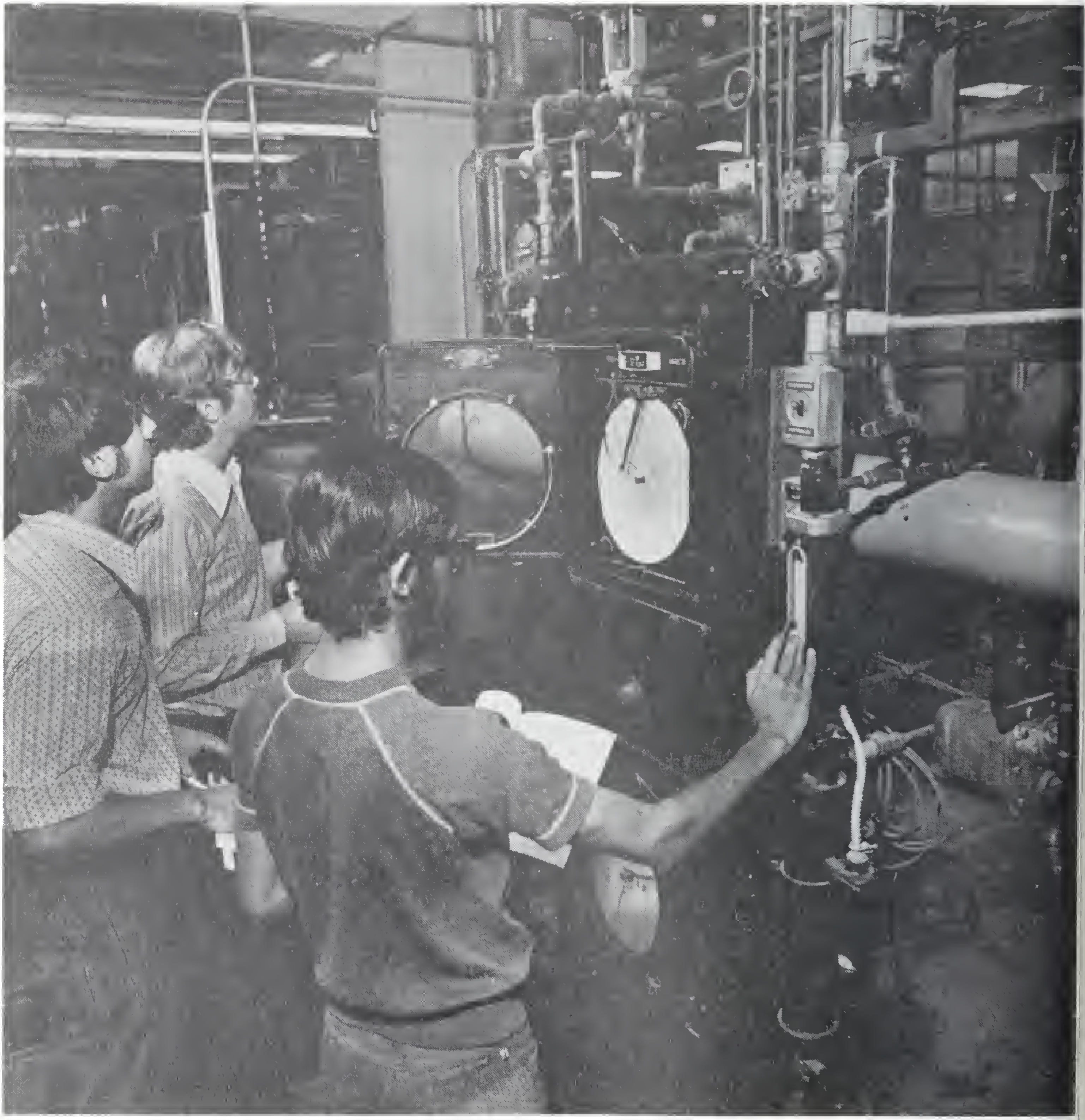

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1973–74

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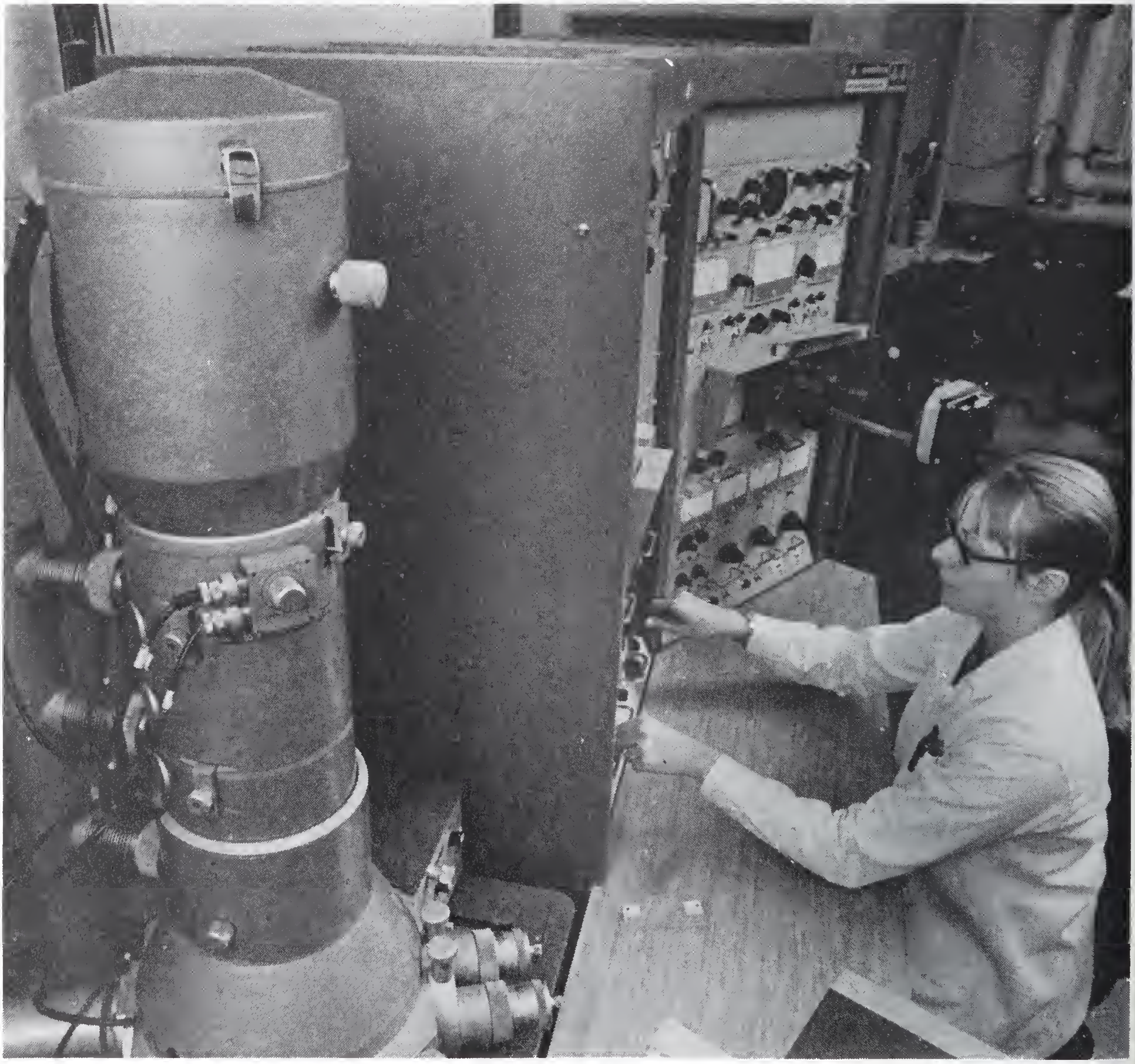

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